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BOMEX BULLETIN NO. 6

MARCH 1970

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I. INTRODUCTION

BOMEX Bulletin No. 6 outlines BOMAP (Barbados Oceanographic and Meteorological Analysis Project) plans for the BOMEX "Core" experiment analysis, BOMEX data processing, and BOMEX statistical analyses, and includes a section on BOMEX Participants Information Exchange that indicates progress and current status of projects, expected dates of availability for project data, and reports and papers derived from BOMEX data.

II. BOMAP PLAN OF WORK

A. General Structure

A BOMAP Office has been established within ESSA's Research Laboratories with its headquarters at Rockville, Maryland. The organizational structure of BOMAP is described in BOMEX Bulletin No. 5. The following sections describe the plan of work in greater detail. The major tasks are divided into three areas of activity (fig. 1). Figures 2, 3, and 4 show the plan of work in each of these divisions.

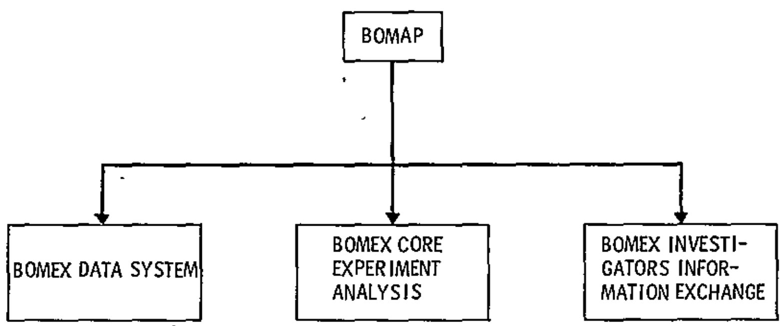

Figure 1.--Major task areas of BOMAP.

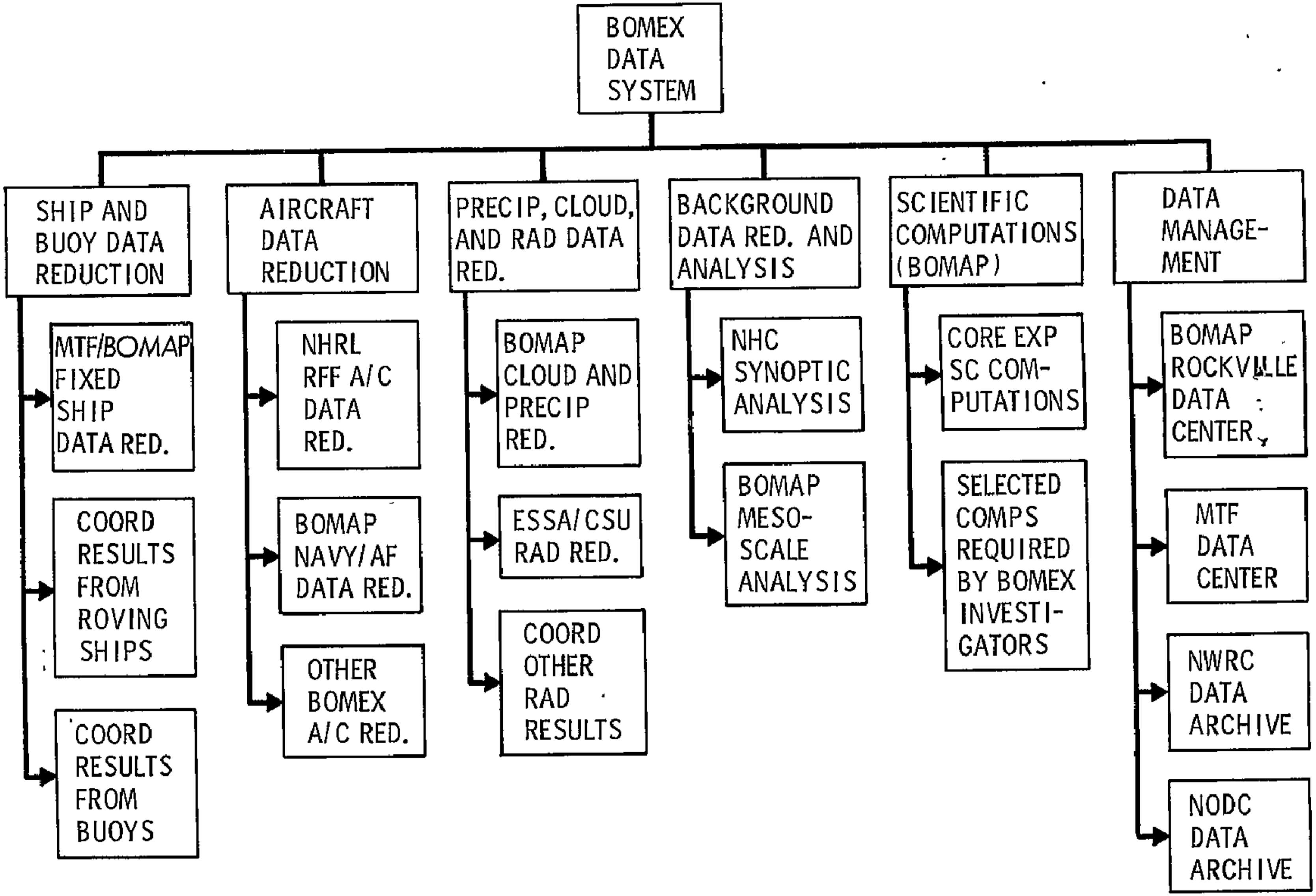

Figure 2.--BOMEX Data System.

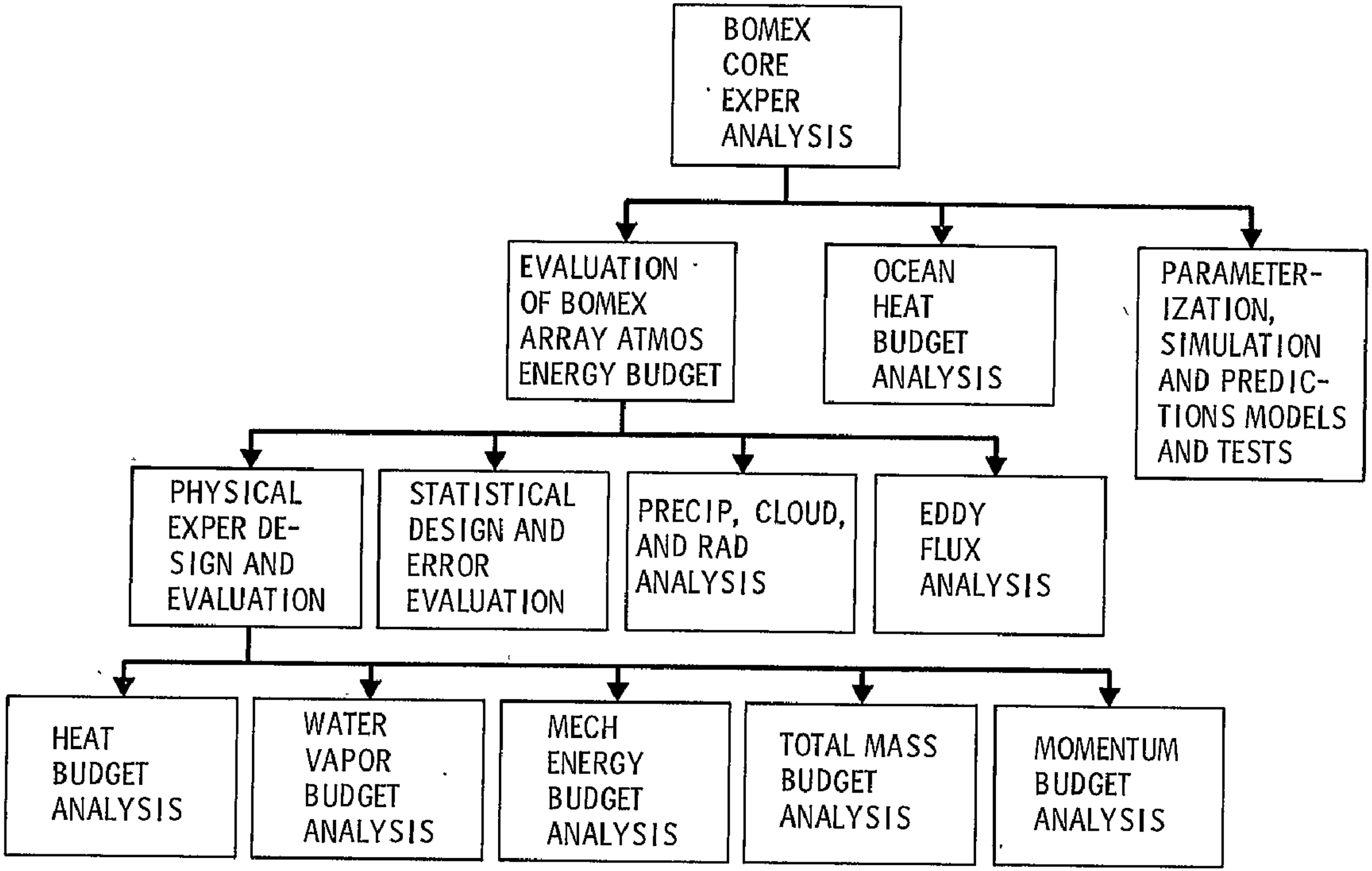

Figure 3.--BOMEX Core Experiment Analysis.

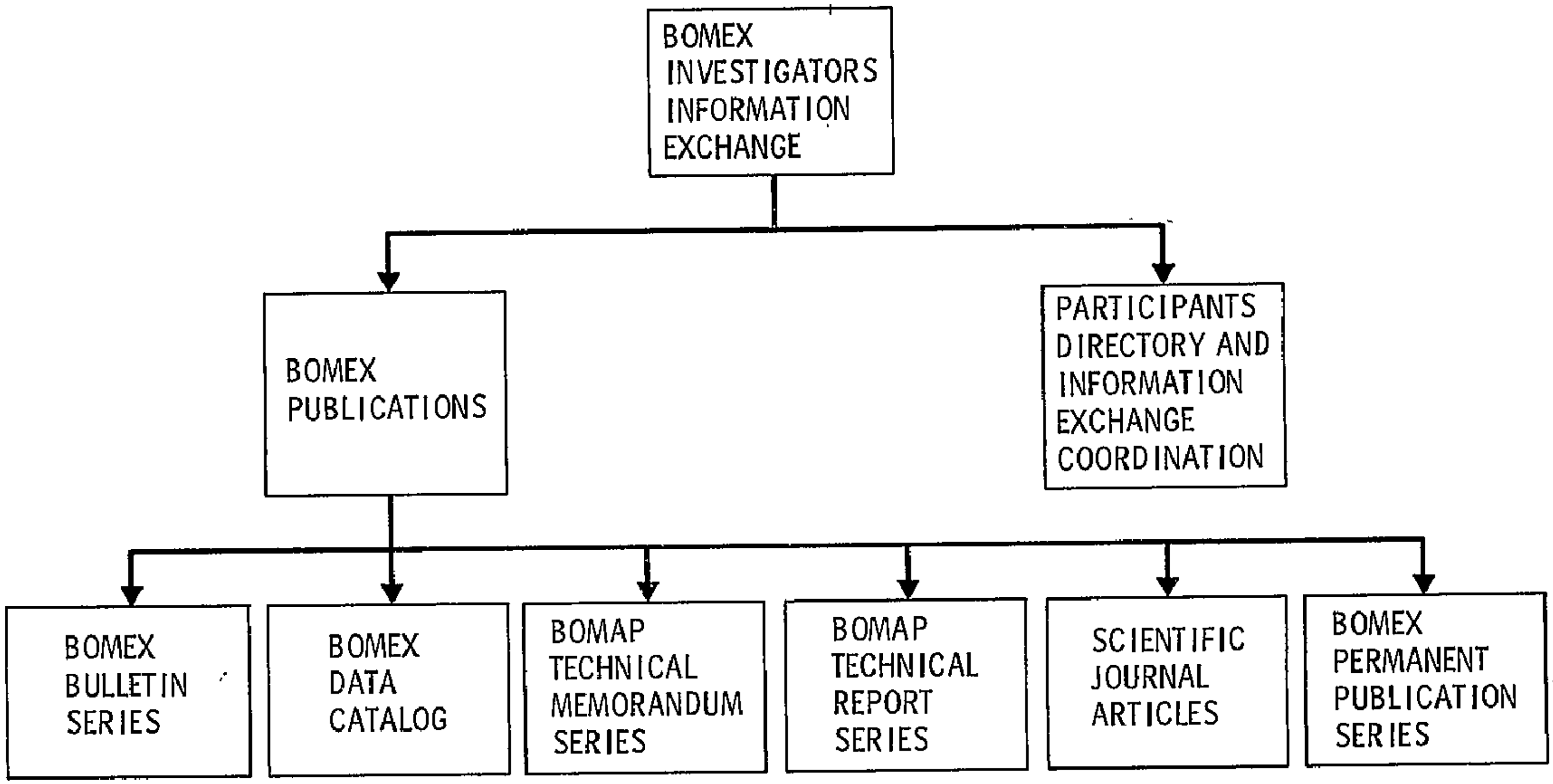

Figure 4.--BOMEX Investigators Information Exchange.

Data Management

The BOMEX Data System was shown in figure 2. The BOMEX Data Management System is illustrated in figure 5. It begins with the BOMEX data, includes the reduction and analysis of the data, and ends with publication of results, techniques, and data catalogs, and establishment of data archives.

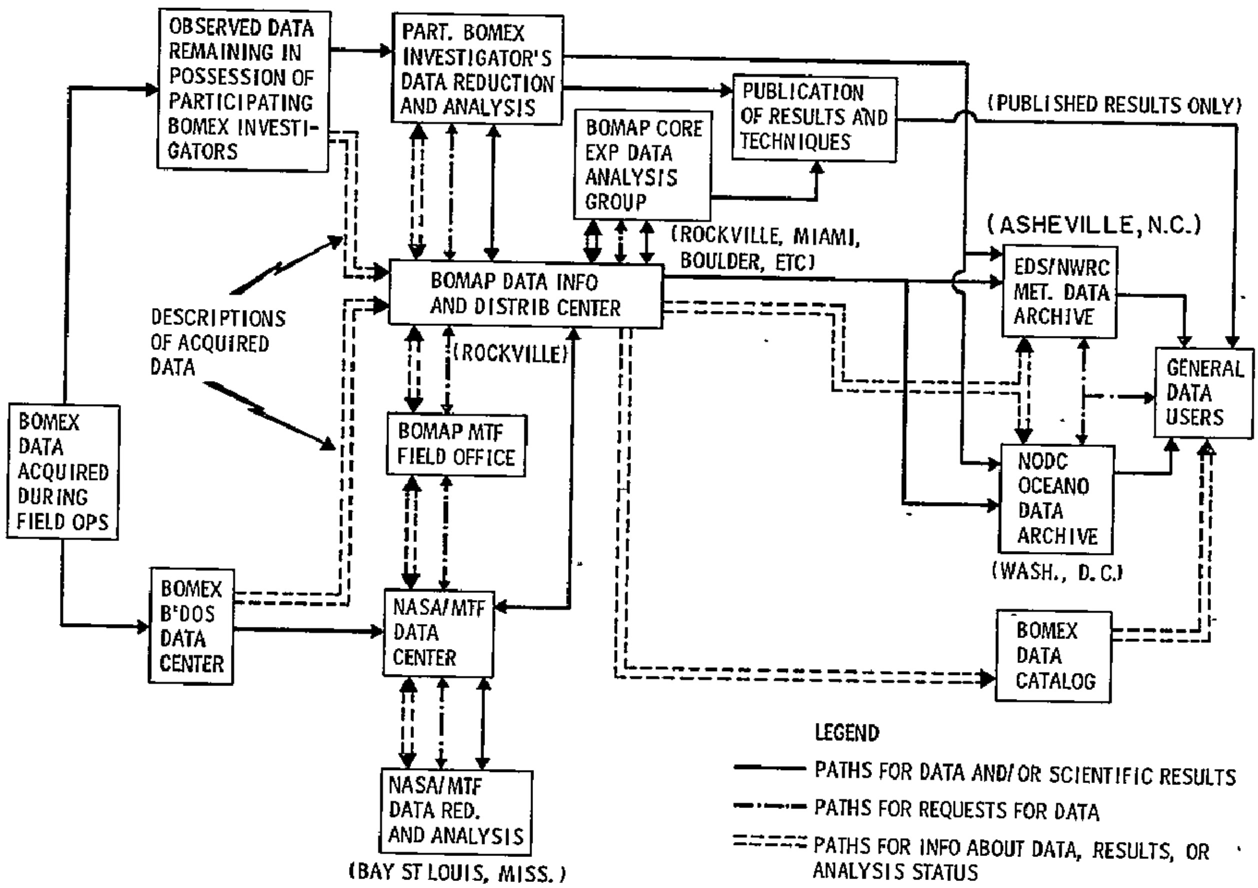

Figure 5.--BOMEX Data Management System.

Target dates for reduction, validation, analyses, and documentation of BOMEX data follow:

BOMEX data catalog	4 / 15 / 70
Preliminary reduction of complete 4th period RFF data available to principal investigators only (U. of Miami)	4 / 15 / 70
Complete RFF Gust Probe/Refractometer data reduction, preliminary analysis and documentation (Rinaldi)	5 / 15 / 70
Complete RFF radar and cloud photo catalog (RFF)	5 / 15 / 70
Complete AF dropsonde reduction	5 / 31 / 70
BOMEX Bulletin No. 7	6 / 15 / 70
Complete ship surface observation validation	6 / 30 / 70
Complete periods 1-3 RFF line-integral data reduction (NHRL)	6 / 30 / 70
Complete AF B-57 photomosaic production and documentation	6 / 30 / 70
Manually reduced fixed-ship rawinsondes for periods 3-4	6 / 30 / 70
Complete final 4th period RFF data reduction (NHRL) and documentation of RFF meteorological/navigation data reduction	7 / 31 / 70
Complete DISCOVERER and Island radar data reduction	8 / 31 / 70
Complete fixed-ship track analysis (C&GS)	8 / 31 / 70
Complete Navy C-121 and AF C-130 meteorologocal and navigation data reduction and documentation	8 / 31 / 70
BOMEX Bulletin No. 8	9 / 15 / 70
Begin final reduction of BOOM, RAWIN, and STD data (A process)	11 / 30 / 70
Complete precipitation analysis and documentation of DISCOVERER, Island and AF B-47 radar data	11 / 30 / 70
BOMEX Bulletin No. 9	12 / 15 / 70

Complete analysis of RFF Gust Probe/Refractometer water vapor flux data	12 / 31 / 70
Complete BOOM, RAWIN and STD data reduction	1 / 31 / 71
Complete BLIP data reduction and documentation	1 / 31 / 71
Complete analysis of RFF radar and photo data for BOMEX periods 1-3	2 / 28 / 71
Complete precipitation/radiation analysis and documentation of AF B-57 photos and ATS, ESSA, and NIMBUS pictures	2 / 28 / 71
BOMEX Bulletin No. 10	3 / 15 / 71
Complete documentation of BOMEX fixed-ship data reduction	3 / 31 / 71
Preliminary analysis of BLIP data	3 / 31 / 71
Complete BOMEX precipitation analysis and documentation	4 / 30 / 71
Complete BOMEX radiation analysis and documentation (Colo. State U.)	4 / 30 / 71
Complete BOMEX oceanic heat budget	4 / 30 / 71
Complete BOMEX microscale eddy-flux analysis	4 / 30 / 71
Complete mesoscale analysis for periods 1-3	5 / 15 / 71
BOMEX Bulletin No. 11	6 / 15 / 71
Complete documentation of BOMEX mesoscale analysis, ocean heat budget analysis and microscale eddy-flux analysis	6 / 30 / 71
Complete reanalysis of tropical Atlantic synoptic maps for all BOMEX periods (NHC)	6 / 30 / 71
BOMEX Bulletin No. 12	9 / 15 / 71
Complete final BOMEX data catalog	9 / 30 / 71
Complete BOMEX atmospheric mass, energy and momentum budget analysis	9 / 30 / 71
BOMEX Bulletin No. 13	12 / 15 / 71
Complete BOMEX parameterization test	12 / 31 / 71
BOMEX Bulletin No. 14	3 / 15 / 72
Complete documentation of BOMEX Core Experiment, including parameterization test	3 / 31 / 72
BOMEX Bulletin No. 15	6 / 15 / 72
Complete BOMEX Permanent Publication Series	6 / 30 / 72

Core Experiment Data

The BOMEX core experiment was concerned with the evaluation of the energy budget of the atmospheric volume and the heat budget of the upper oceanic portion of the BOMEX cube, and with the energy fluxes through the sea-air interface. The BOMEX cube was a volume 500 x 500 km on each side extending from approximately the 500-mb pressure surface to a depth of 300 meters in the ocean. Figure 6 is a schematic diagram of the fluxes involved. F_H and F_T denote the horizontal and upward flux out of the atmospheric volume, F_o the flux from the ocean to the atmosphere, F_{HS} and F_B the horizontal and downward flux out of the oceanic volume. S and S_S represent the source terms in the atmosphere and sea, respectively.

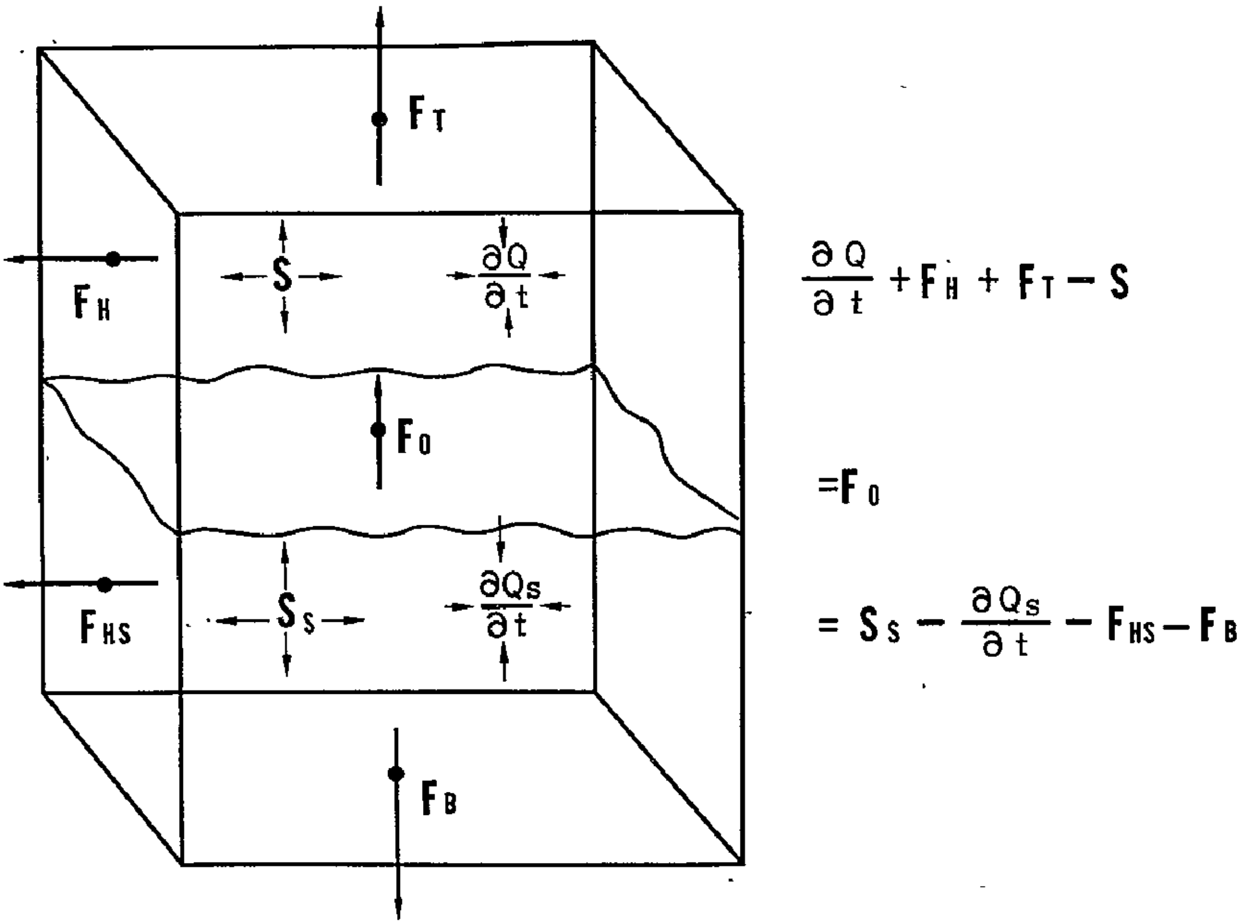

Figure 6.--Core experiment schematic.

In order to measure the various fluxes, observations were taken at many points within and around the perimeter of the BOMEX cube. Figure 7 shows the generalized pattern of atmospheric, sea surface, and oceanic observations. Five ships occupied fixed positions at the four sea surface corners and center of the array. These fixed ships (FS) made surface air, upper air, sea surface, and oceanographic measurements, including observations by specially instrumented devices -- the meteorological boom, BLIP (Boundary Layer Instrument Package), rawinsondes, and STD (salinity, temperature, and depth) measurements in the ocean. Aircraft flights around the perimeter of the BOMEX cube collected data for line-integral and other computations -- the line-integral flight tracks. Aircraft, flying at 20,000 feet across the top of the BOMEX cube, released dropsondes (denoted by parachute symbols in the diagram).

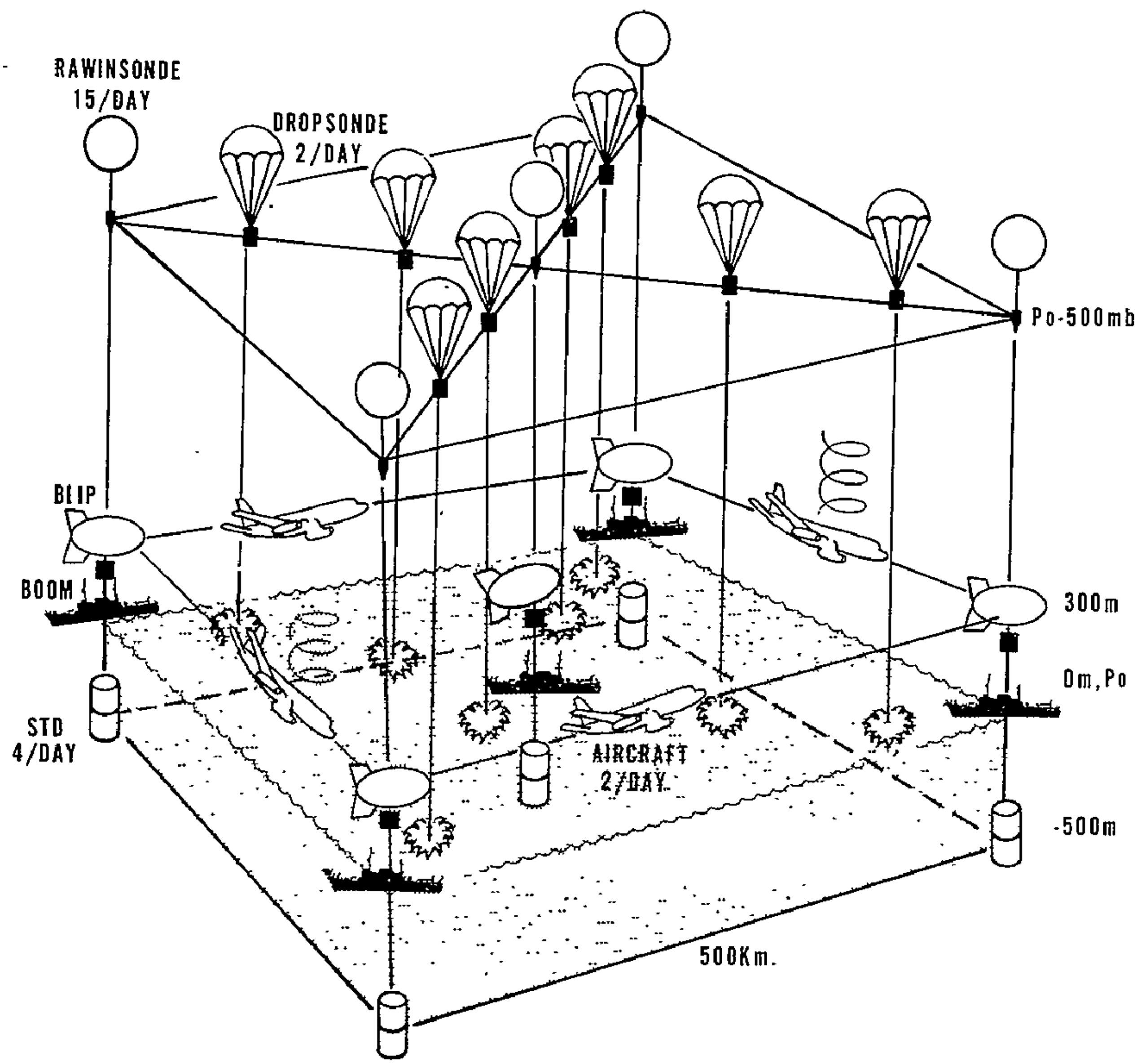

Figure 7.--BOMEX observational array.

In addition to the line-integral flight tracks shown in BOMEX Bulletin No. 4, two other patterns were flown. 1) During May, the night line-integral flight pattern (LIN) was replaced by that illustrated in figure 8. The entire circuit was accomplished by one Navy WC-121 aircraft. The line-integral legs consisted of 100-n.mi. segments at 1000 feet along a portion of each side of the BOMEX square. Stepped soundings were taken at H, K, J, I, and again at H. 2) During June, multiple-level line-integral flights were made as shown in figure 9 at 1000-, 4000-, and 7000-foot levels. Four aircraft were employed in this pattern. Intercomparison legs were flown by pairs of aircraft enroute to and from their initial stations in the array. "Calibration boxes" were executed by each aircraft at each corner of the BOMEX square. On several occasions additional aircraft flew integral patterns at higher altitudes.

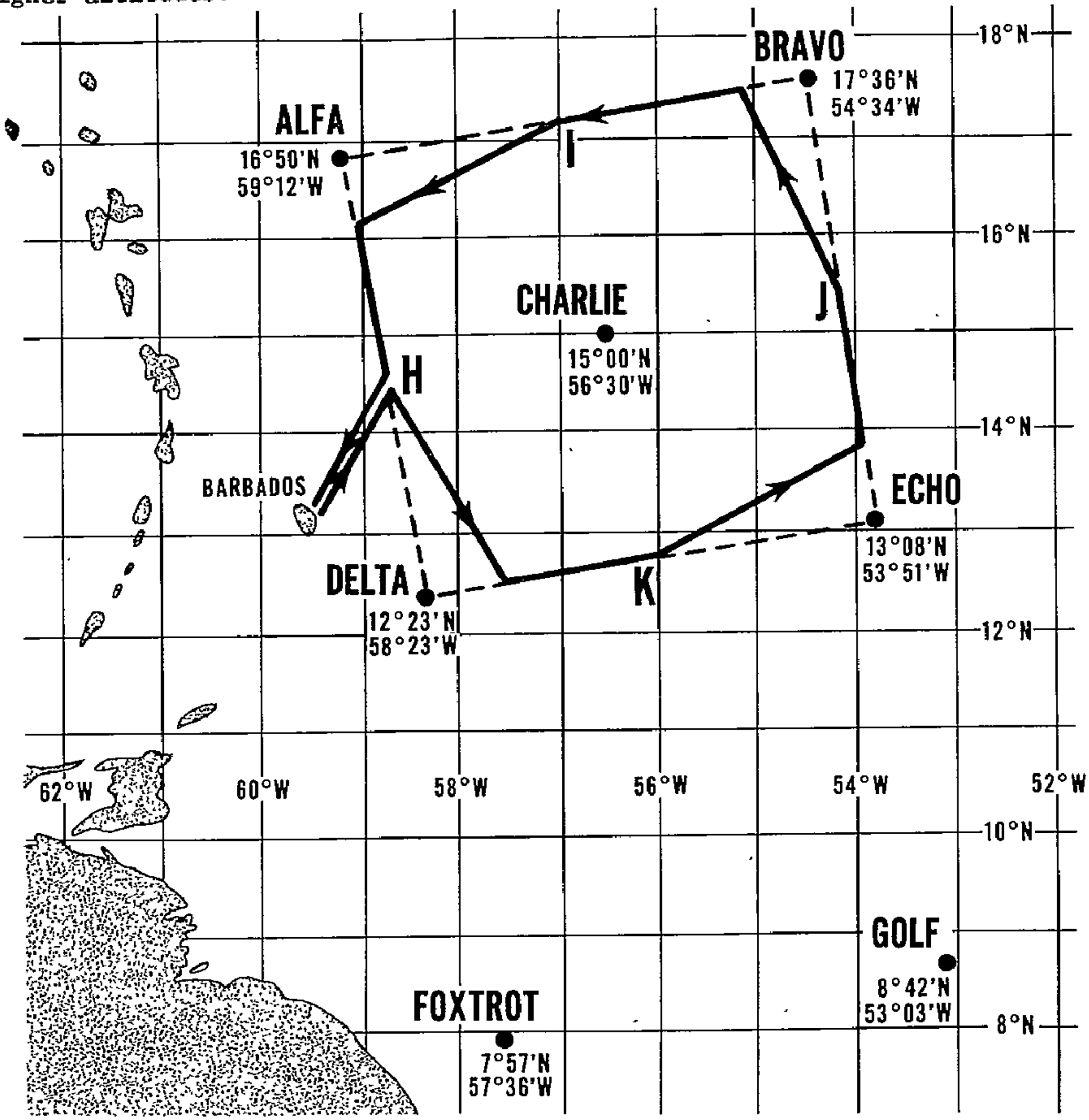

Figure 8.--Night line-integral flight pattern.

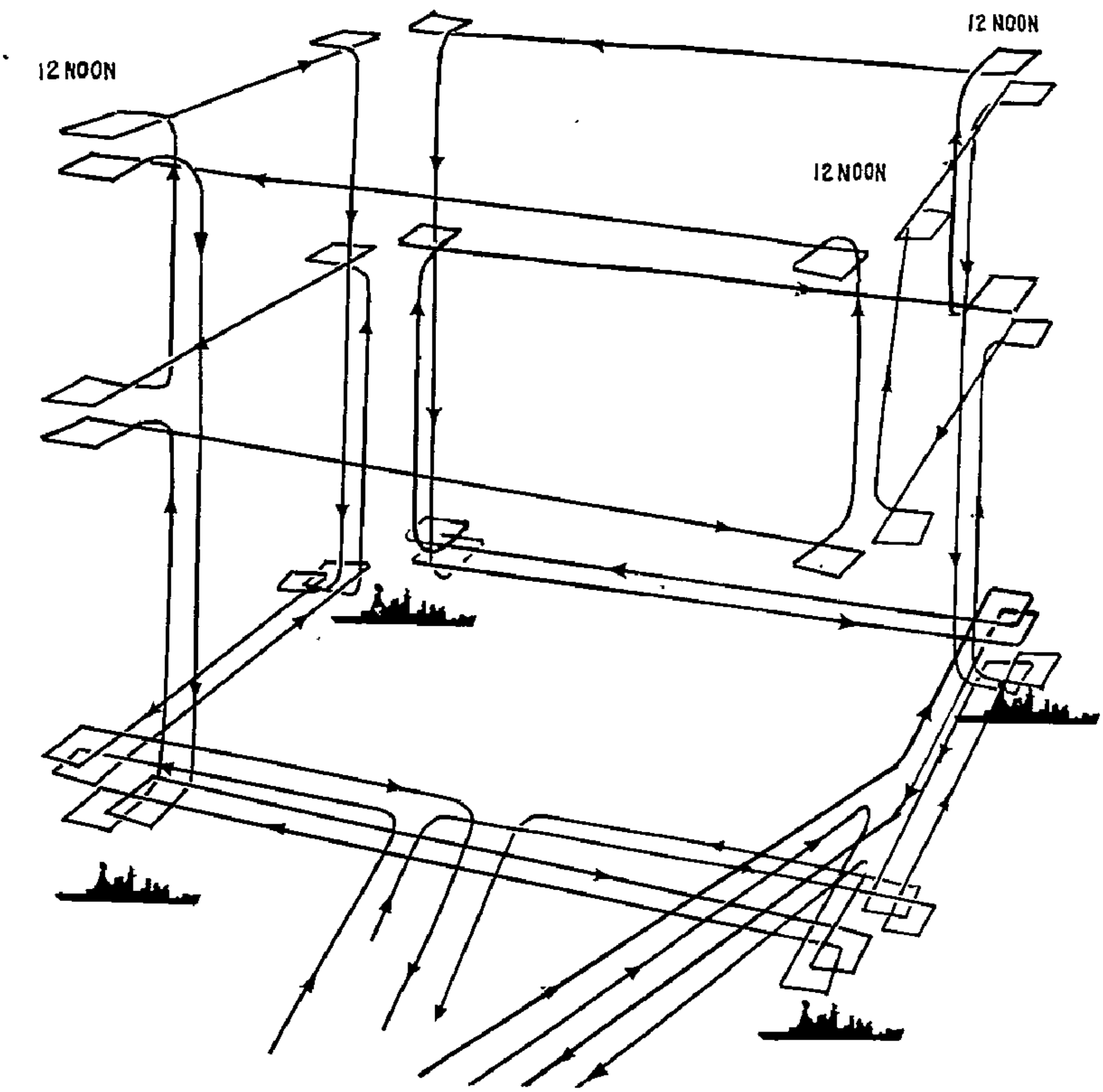

Figure 9.--Multiple-level line-integral flight pattern.

B. Core Experiment Analysis Plan

The core experiment consists of a comparison of estimates of sea-air exchange of energy by the "integral" and "aerodynamic" methods with direct measurements by eddy-covariance methods. The following budgets are involved:

Atmospheric:

Mass	Kinetic energy
Heat (enthalpy)	Total energy
Latent energy	Momentum

Oceanic Heat

In this work, $\overline{X}$ refers to an area average of any quantity and X'' the deviation from the area average. $[X]$ refers to an average of a line integral and X' the deviation from this average. All integrations will be carried out in a p* coordinate system, where p*, the pressure differential, is 0 at the sea surface (fig. 10). The notation used in the budget equations is defined in figure 11.

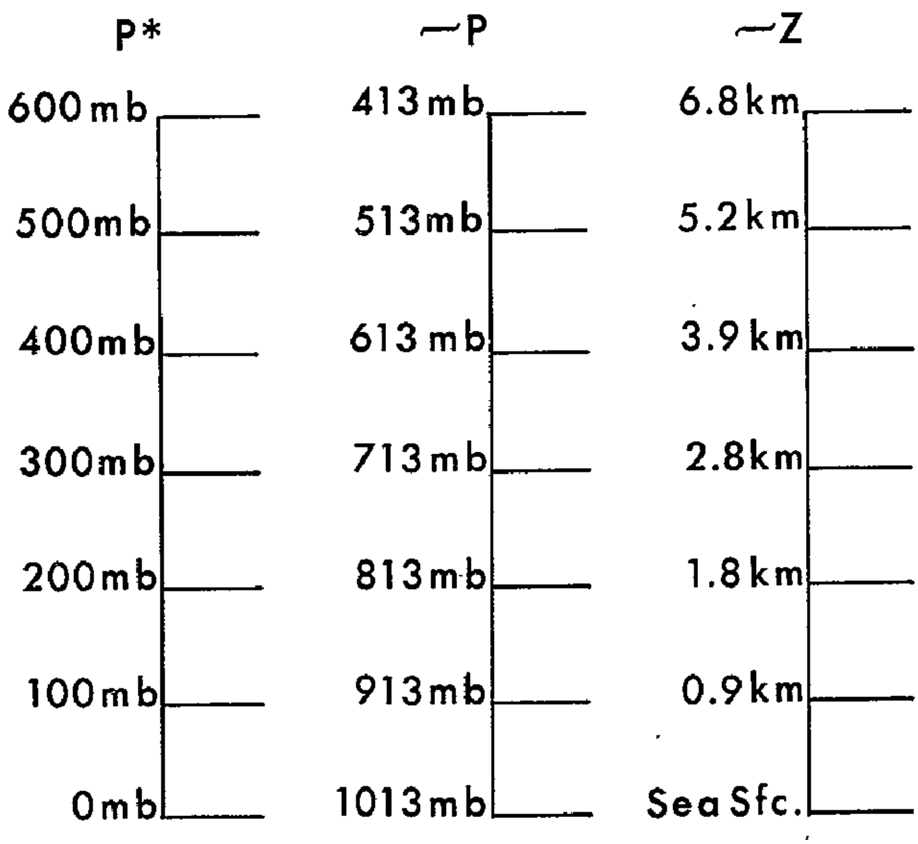

Figure 10.--p* coordinate system, where $p^* = p_o - p$.

p = pressure

p_o = sea level pressure

$p^* = p_o - p$ = pressure differential

$\omega^* = dp^*/dt$ = vertical velocity in p^* system

g = gravitational acceleration

$\mathbf{V}$ = horizontal wind velocity

U, V = eastward and northward components

C = perimeter of integration volume on a p^* surface

A = horizontal area of integration volume

V_n = outward normal wind component along perimeter

ϕ, λ = latitude, longitude

Φ = geopotential = gZ; Z = height above sea level

a = radius of the earth

Ω = angular velocity of earth

f = Coriolis parameter = $2\Omega \sin \phi$

α = specific volume

$\mathbf{F}$ = frictional acceleration

K = kinetic energy per unit mass = $(U^2 + V^2)/2$

H = specific enthalpy = C_pT

τ_ϕ, τ_λ = components of microscale stress

F_H^*, D = microscale upward flux of heat and water vapor

L = latent heat of evaporation of water

q = specific humidity

c, e = condensation and evaporation rates in the atmosphere

E = evaporation rate at the sea surface

p_T^*, U_T, D_T, etc. = values at top of integration volume

Figure 11.--Notation used in budget equations.

In the mass budget equation and analysis shown in figures 12 and 13, the top of the integration "volume" is defined by a set value of p*. Thus the mass contained in this "volume" is constant.

$$\frac{C}{A}\int_{0}^{P_T^*} \left[V_n \right] \frac{dp^*}{g} = - \frac{\overline{\omega_T^*}}{g}$$

Figure 12.--Mass budget equation.

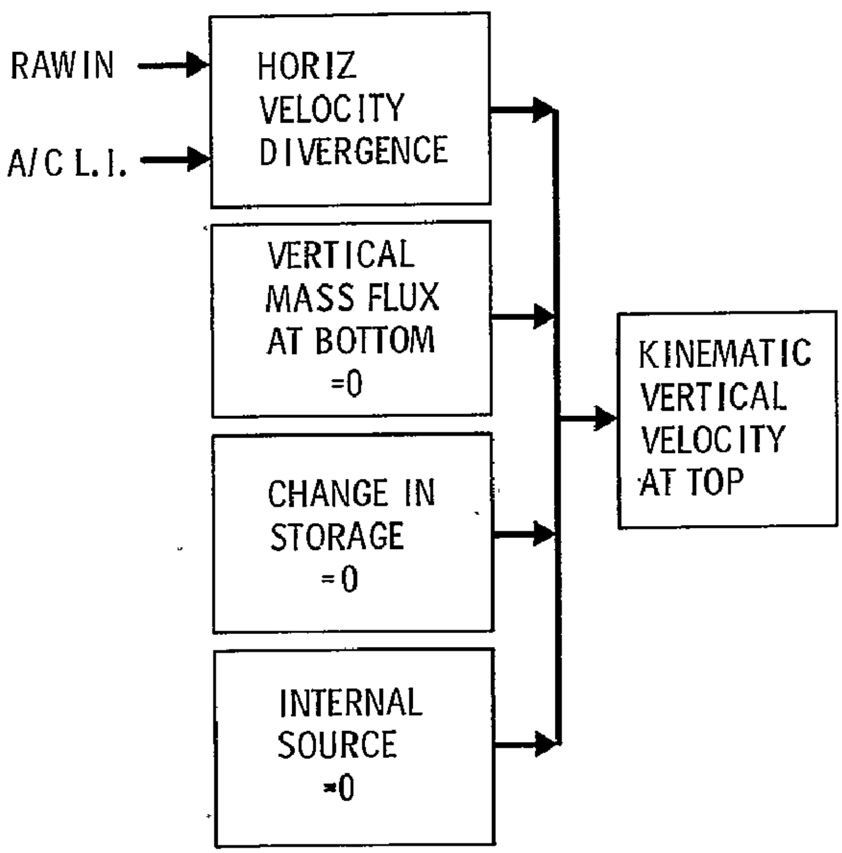

Figure 13.--Mass budget analysis.

The heat (enthalpy) budget equation is shown in figure 14. The mass and heat budgets can be analyzed together, providing both "kinematic" and "adiabatic" estimates of both the vertical velocity and the horizontal divergence. The plan for these combined analyses is diagrammed in figure 15. A slicewise technique is used in which the BOMEX box is divided into a set of smaller working boxes or slices each 25 mb of pressure differential high.

$$\frac{\partial}{\partial t}\int_0^{P_T^*}\bar{H}\frac{dp^*}{g} = -\frac{C}{A}\int_0^{P_T^*}\left\{[H][V_n] + [H'V_n']\right\}\frac{dp^*}{g} - \frac{\bar{H}_T\bar{\omega}_T^*}{g}$$

$$-\frac{\overline{(H''\omega^{*''})}_T}{g} + \frac{1}{g}\left\{\left(\bar{F}_{RAD}\right)_0 - \left(\bar{F}_{RAD}\right)_T + \left(\bar{F}_H^*\right)_0 - \left(\bar{F}_H^*\right)_T\right\}$$

$$+\int_0^{P_T^*}\overline{L(c-e)}\frac{dp^*}{g} - \int_0^{P_T^*}\overline{\mathbb{F}\bullet\mathbb{V}}\frac{dp^*}{g}$$

$$+\int_0^{P_T^*}\overline{\frac{\alpha\partial P}{\partial t}}\frac{dp^*}{g} + \int_0^{P_T^*}\alpha\,\overline{\mathbb{V}\bullet\nabla P_0}\,\frac{dp^*}{g}$$

$$-\int_0^{P_T^*}\left\{\bar{\alpha}\,\bar{\omega}^* + \overline{\alpha''\omega^{*''}}\right\}\frac{dp^*}{g}$$

Figure 14.--Heat (enthalpy) budget equation.

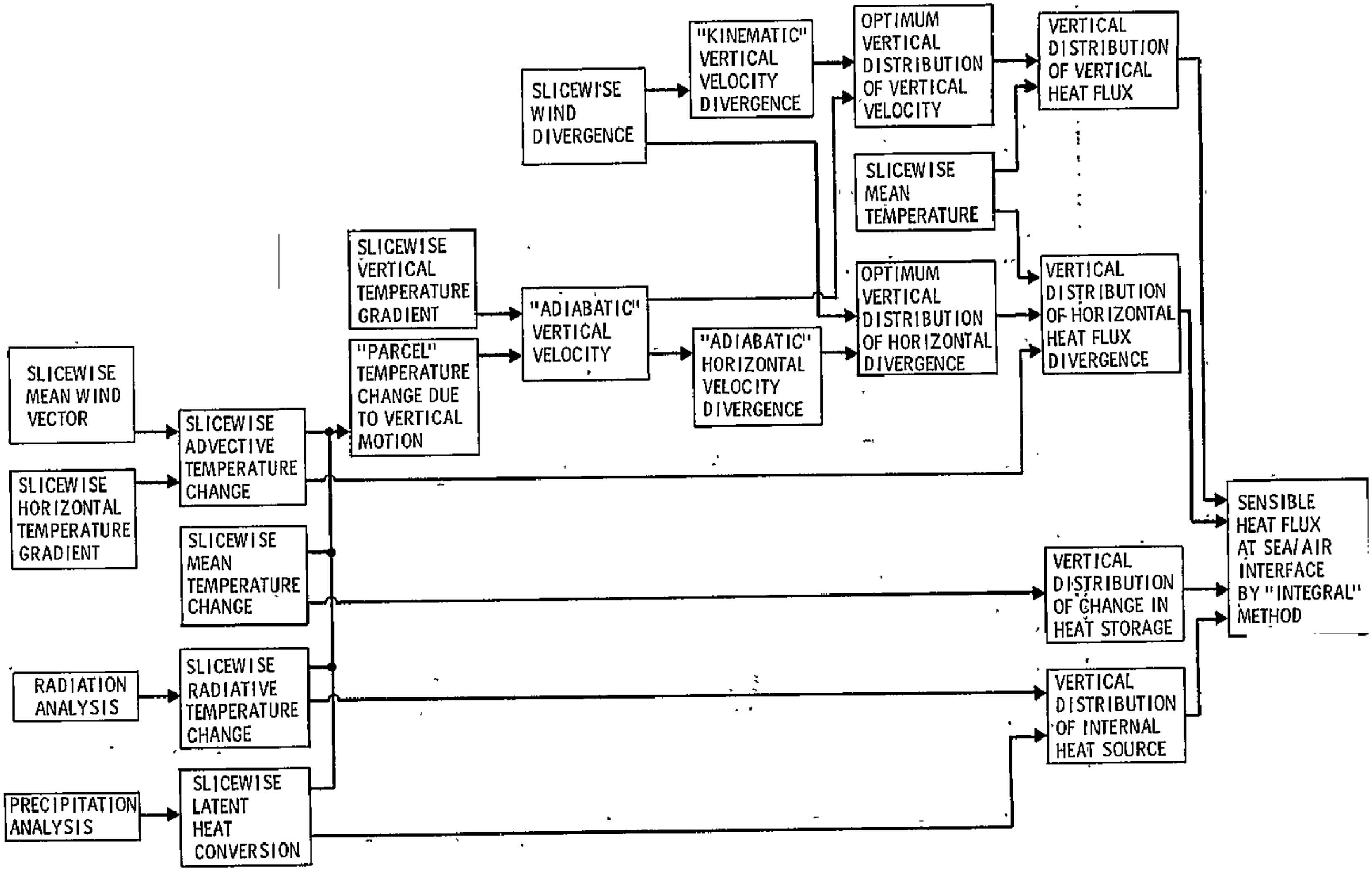

Figure 15.--Mass and heat budget analysis.

The latent energy budget equation is given in figure 16. The kinetic energy budget equation and analysis plan is shown by figures 17 and 18. The total energy budget equation is given in figure 19.

$$\frac{\partial}{\partial t}\int_0^{P_T^*} L\bar{q}\,\frac{dp^*}{g} = -\frac{C}{A}\int_0^{P_T^*} L\left\{[q][V_n]+[q'V_n']\right\}\frac{dp^*}{g}$$

$$-\frac{L\,\overline{q_T}\,\overline{\omega_T^*}}{g} \quad -\frac{\overline{L(q''\omega^{*''})}_T}{g} \quad -\int_0^{P_T^*}\overline{L(C-e)}\,\frac{dp^*}{g}$$

$$+\bar{E}-\bar{D}_T$$

$$\text{where } \bar{D}_0 \equiv \bar{E}$$

Figure 16.--Latent energy budget equation

$$\frac{\partial}{\partial t}\int_0^{P_T^*}\overline{K}\,\frac{dp^*}{g} = -\frac{C}{A}\int_0^{P_T^*}\left\{[K][V_n]+[K'V_n']\right\}\frac{dp^*}{g} - \frac{\overline{K_T W_T^*}}{g}$$

$$-\int_0^{P_T^*}\overline{\alpha \mathbb{V}\cdot\nabla P_0}\,\frac{dp^*}{g} - \int_0^{P_T^*}\overline{\mathbb{V}\cdot\nabla\Phi}\,\frac{dp^*}{g} + \int_0^{P^*}\overline{\mathbb{F}\cdot\mathbb{V}}\,\frac{dp^*}{g}$$

Figure 17.--Kinetic energy budget equation.

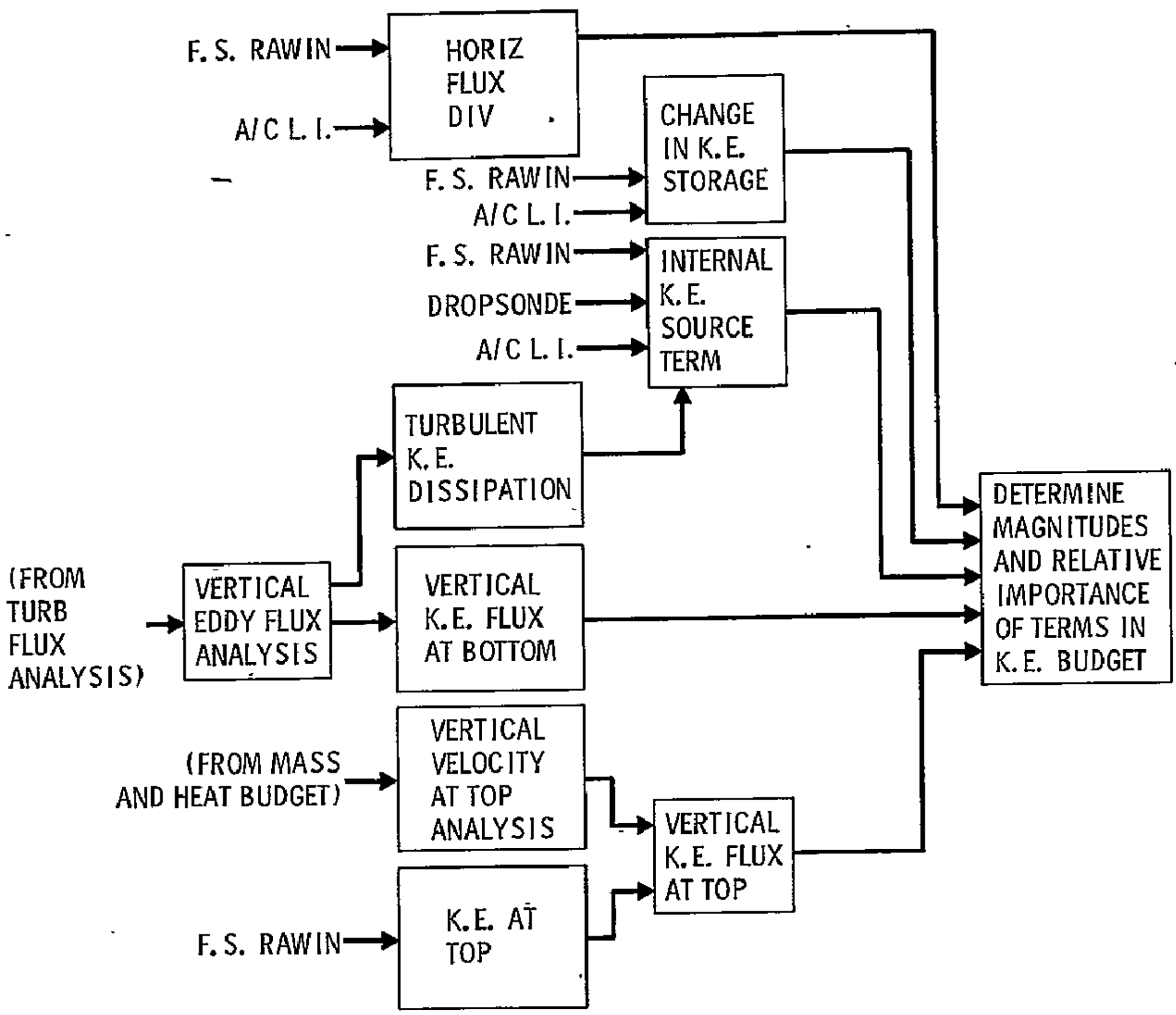

Figure 18.--Kinetic energy budget analysis.

$$\frac{\partial}{\partial t}\int \overline{K+\Phi+H+Lq}\,\frac{dp^*}{g} = -\frac{C}{A}\int_0^{P_T^*}\left\{[K]+[\Phi]+[H]+L[q]\right\}[V_n]\frac{dp^*}{g}$$

$$-\frac{C}{A}\int\left[\left(K'+\Phi'+H'+Lq'\right)V_n'\right]\frac{dp^*}{g} - \left\{\overline{K}_T+\overline{\Phi}_T+\overline{H}_T+L\overline{q}_T\right\}\overline{\omega^*}_T$$

$$-\overline{\left\{K''+\Phi''+H''+Lq''\right\}\omega_T^{*\prime\prime}}$$

$$+\frac{1}{g}\left\{(\overline{F}_{RAD})_0-(\overline{F}_{RAD})_T+(\ddot{\overline{F}}{}_H^*)_0-(\overline{F}_H^*)_T\right\}$$

$$+\int_0^{P_T^*}\overline{\frac{\alpha\,\partial p_0}{\partial t}}\,\frac{dp^*}{g}+\int_0^{P_T^*}\frac{\partial\Phi}{\partial t}\,\frac{dp^*}{g}+\overline{E}-\overline{D}_T$$

Figure 19.--Total energy budget equation.

Conversion of one form of energy to another, which does not appear in the total energy equation, is illustrated by figure 20. Because the p* surface contains both pressure and height variations, kinetic energy can be generated both by the $-\alpha V \cdot \nabla p_0$ and $-V \cdot \nabla \Phi$ terms. Frictional dissipation is represented by $-F \cdot V$, generation of potential energy from heat by upward motion by $\omega^* \alpha$, and conversion of latent to sensible heat by $L\,(e - c)$. $\dot{Q}_{RAD}$ and $\dot{Q}_{SH}$ are the inputs of radiative and sensible heat to the atmosphere.

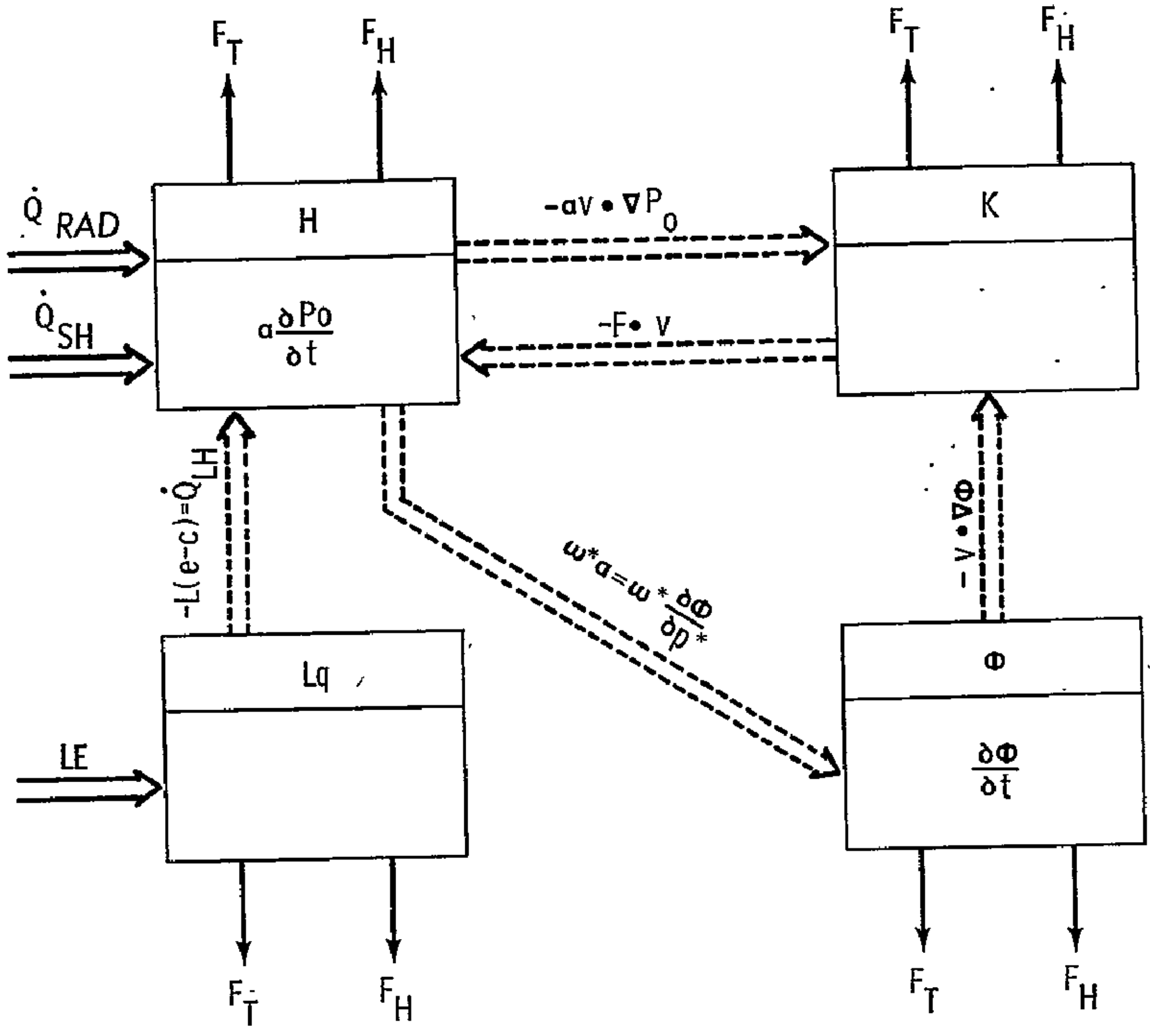

Figure 20.--Energy conversion schematic.

The meridional and zonal momentum budget equations are given in figures 21 and 22. The schematic plan of the momentum budget analysis is given in figure 23. Note that the "geostrophic departure" technique is included in this analysis, which will test the validity of neglecting the other terms in the surface stress equation.

$$\frac{\partial}{\partial t}\int_0^{P_T^*} \overline{V}\,\frac{dp^*}{g} = -\frac{C}{A}\int_0^{P_T^*}\left\{[V][V_n] + [V'V'_n]\right\}\frac{dp^*}{g} - \frac{\overline{V_T\,\overline{\omega}^*{}_T}}{g}$$

$$-\int_0^{P_T^*}\overline{\frac{U^2\tan\phi}{a}}\,\frac{dp^*}{g} - \int_0^{P_T^*}\overline{fU}\,\frac{dp^*}{g}$$

$$-\int_0^{P_T^*}\overline{\frac{\partial Z}{a\partial\phi}}\,\frac{dp^*}{g} - \int_0^{P_T^*}\overline{\frac{\alpha}{a}\frac{\partial P_0}{\partial\phi}}\,\frac{dp^*}{g}$$

$$-\frac{\overline{\left(V''\omega^{*''}\right)_T}}{g} + \left(\overline{\tau}_\phi\right)_T - \left(\overline{\tau}_\phi\right)_0$$

Figure 21.--Meridional momentum budget equation.

$$\frac{\partial}{\partial t}\int_0^{P_T^*} \overline{U}\,\frac{dp^*}{g} = -\frac{C}{A}\int_0^{P_T^*}\left\{[U][V_n] + [U'V'_n]\right\}\frac{dp^*}{g} - \frac{\overline{U_T\,\overline{\omega^*}_T}}{g}$$

$$+\int_0^{P_T^*}\overline{\frac{UV\tan\phi}{a}}\,\frac{dp^*}{g} + \int_0^{P_T^*}\overline{fV}\,\frac{dp^*}{g}$$

$$-\int_0^{P_T^*}\overline{\frac{1}{a\cos\phi}\frac{\partial Z}{\partial\lambda}}\,dp^* - \int_0^{P_T^*}\overline{\frac{\alpha}{a\cos\phi}\frac{\partial P_0}{\partial\lambda}}\,\frac{dp^*}{g}$$

$$-\frac{\overline{\left(U''\omega^{*''}\right)_T}}{g} + \left(\overline{\tau}_\lambda\right)_T - \left(\overline{\tau}_\lambda\right)_0$$

Figure 22.--Zonal momentum budget equation.

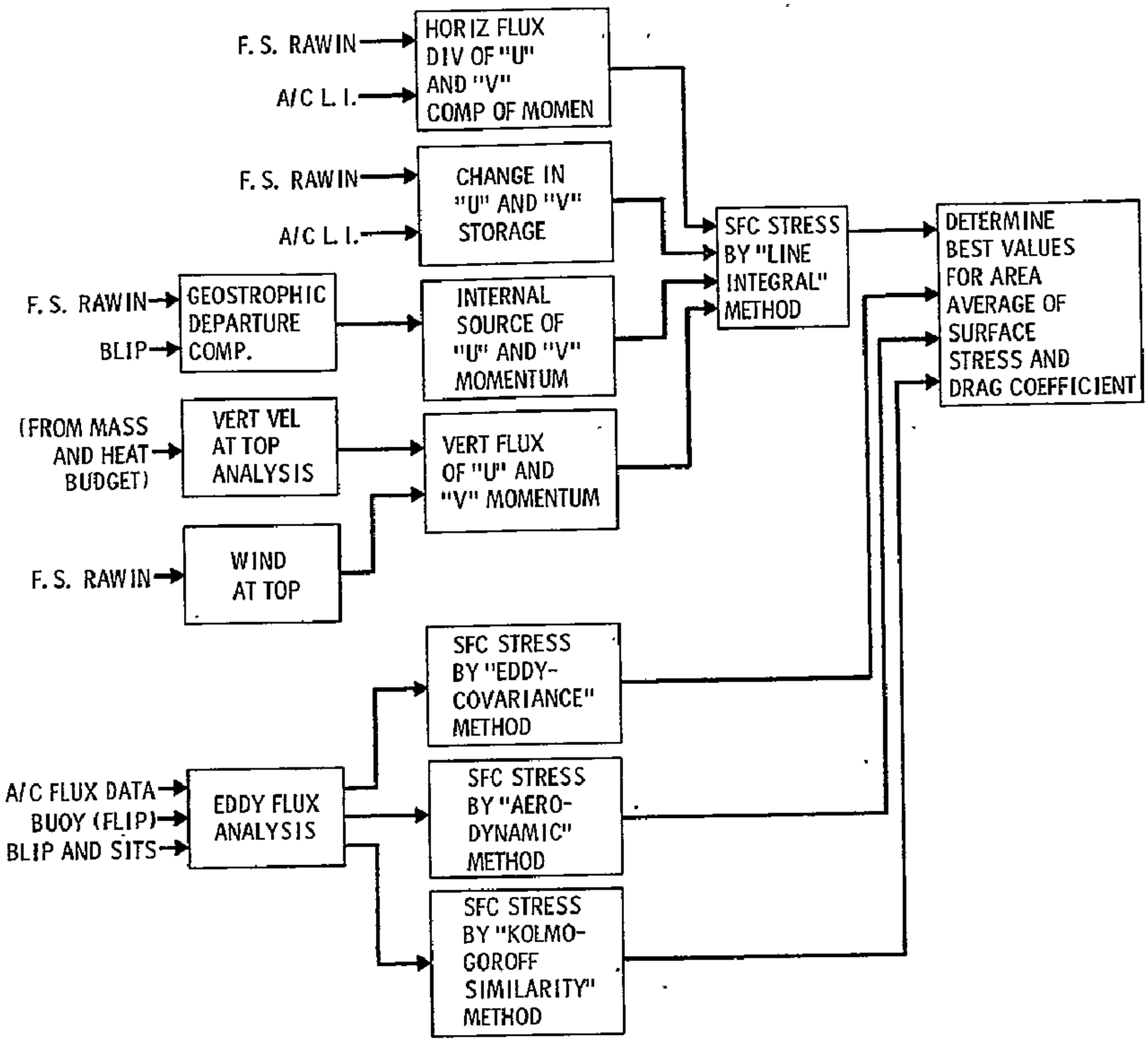

Figure 23.—Momentum budget analysis.

In order to perform the budget analyses certain turbulent flux analyses are required. The plan for using the turbulent flux data is shown by the schematic diagram, figure 24. The area averages of the various interface fluxes obtained from the turbulence analysis will be compared with the corresponding estimates of the flux obtained by the "integral" method shown in preceding illustrations.

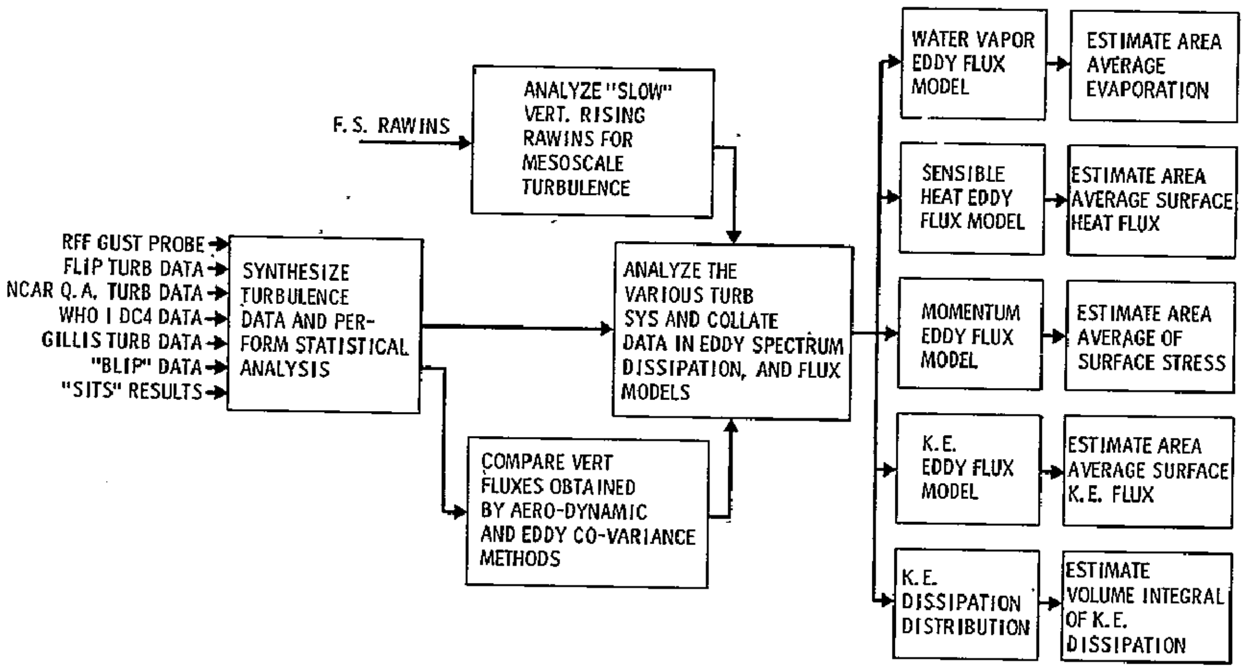

Figure 24.--Turbulent flux analysis.

The ocean heat budget analysis is diagrammed in figure 25. The heat lost from the ocean should provide for the sum of the latent and sensible heat gained by the atmosphere and the net long-wave radiation loss from the sea surface.

The generalized BOMAP data processing sequence is shown in figure 26. This is expanded in figure 27 to show the interaction of the various data sources and scientific analyses. The circled numbers identify the output of the processing stage with the inputs to the subsequent analysis stage.

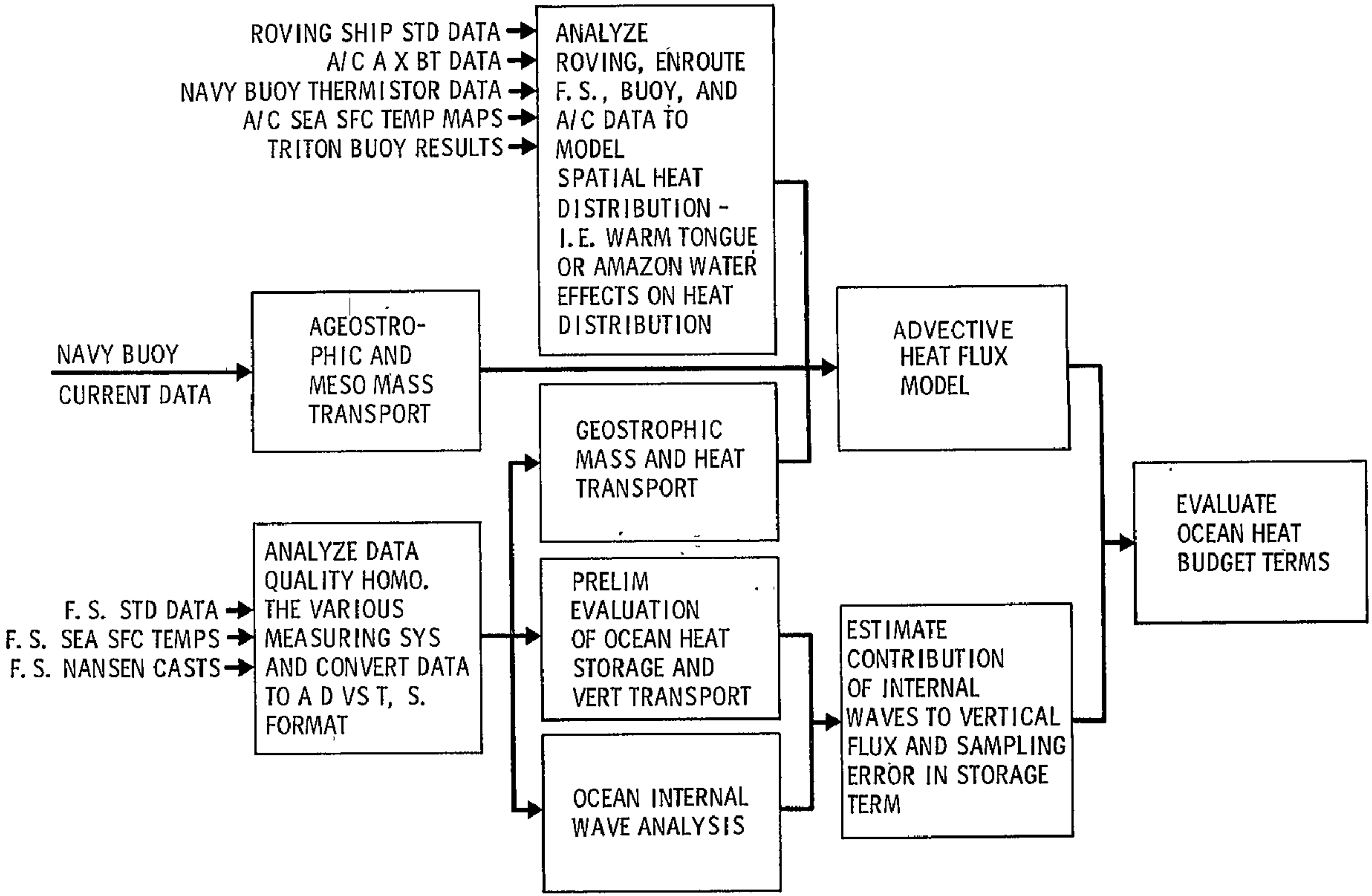

Figure 25.--Ocean heat budget analysis.

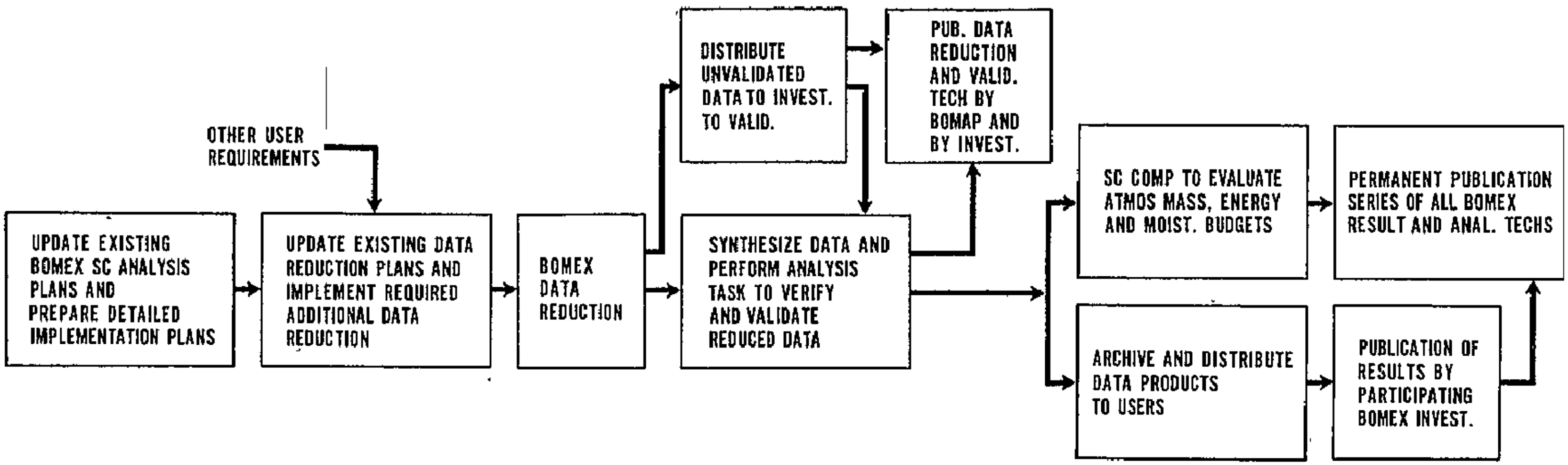

Figure 26.--Generalized BOMAP data processing sequence.

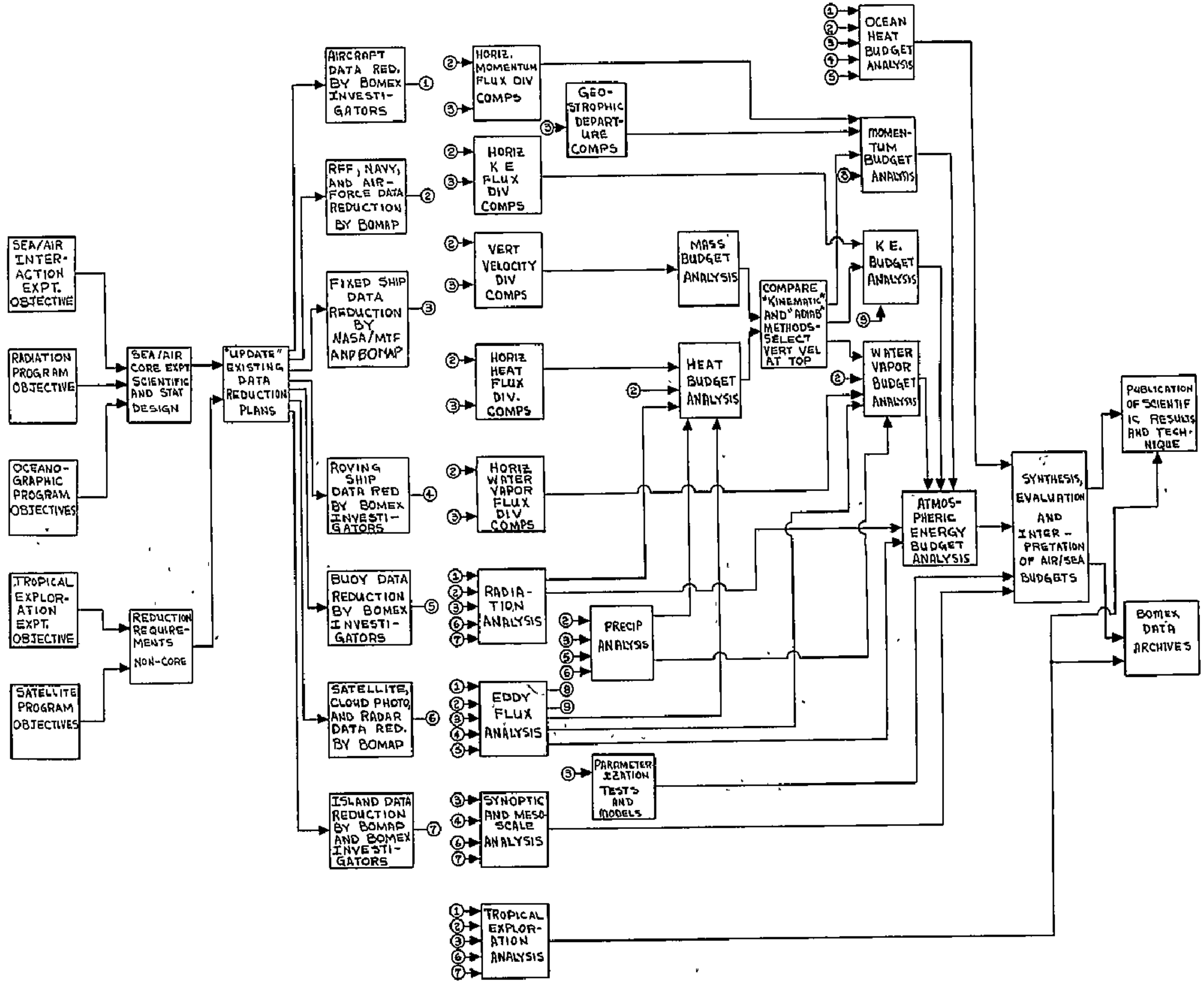

Figure 27.--BOMAP data processing and analysis flow chart.

C. Data Processing Plan

Ship Data Reduction

The ship data reduction, which was described in some detail in BOMEX Bulletin No. 5, is outlined in figures 28, 29, and 30. Agency responsibilities relating to implementation of BOMAP requirements for the SCARD (Signal Conditioning and Recording Device) data reduction system are shown in figure 30. In figure 30 there are three stages (indicated by diamond configuration) built in for checking and validation of the data processing.

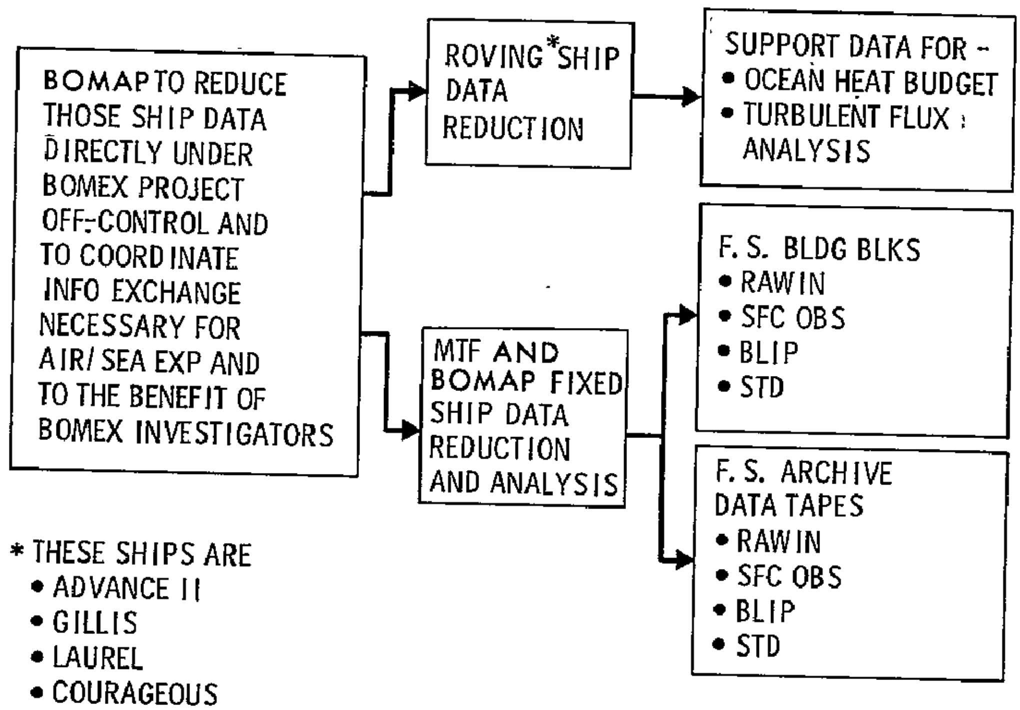

Figure 28.--Ship data reduction plan.

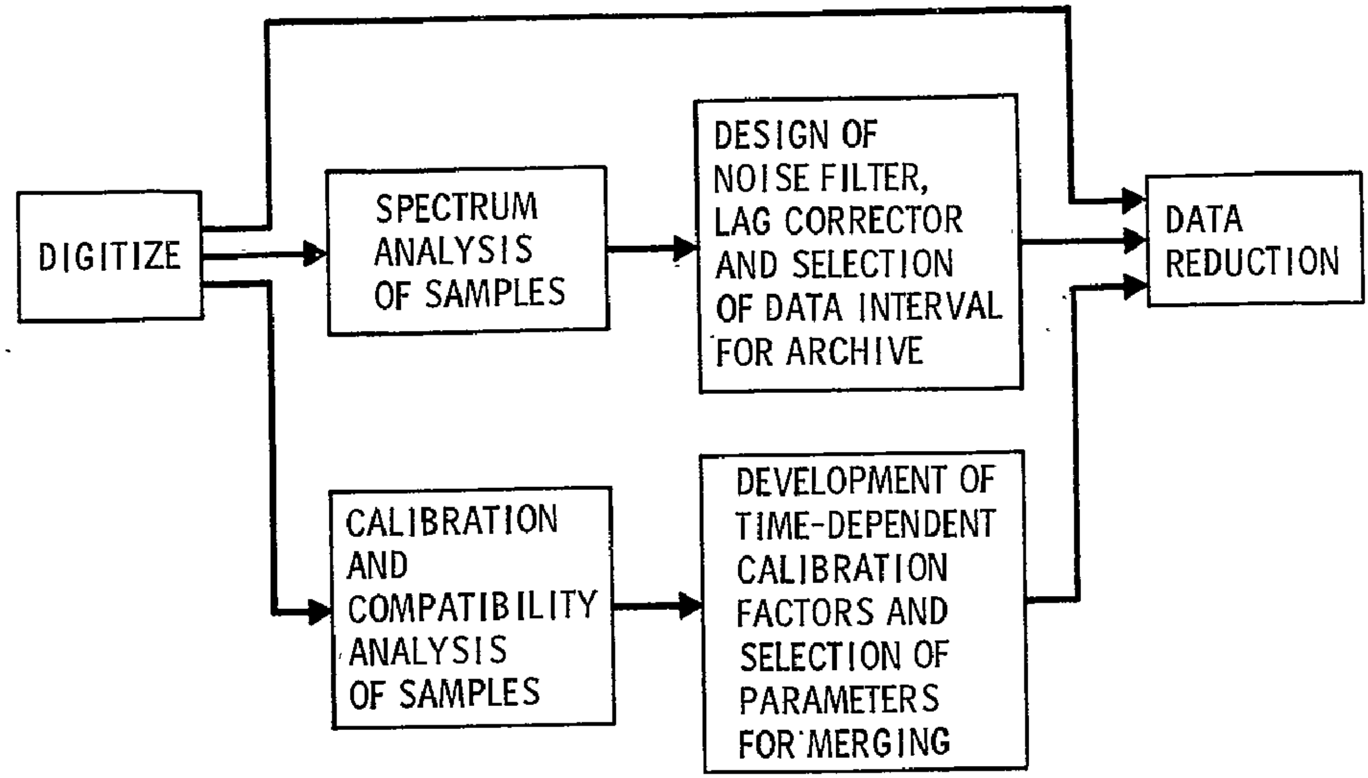

Figure 29.--Ship data analysis and evaluation prior to data reduction.

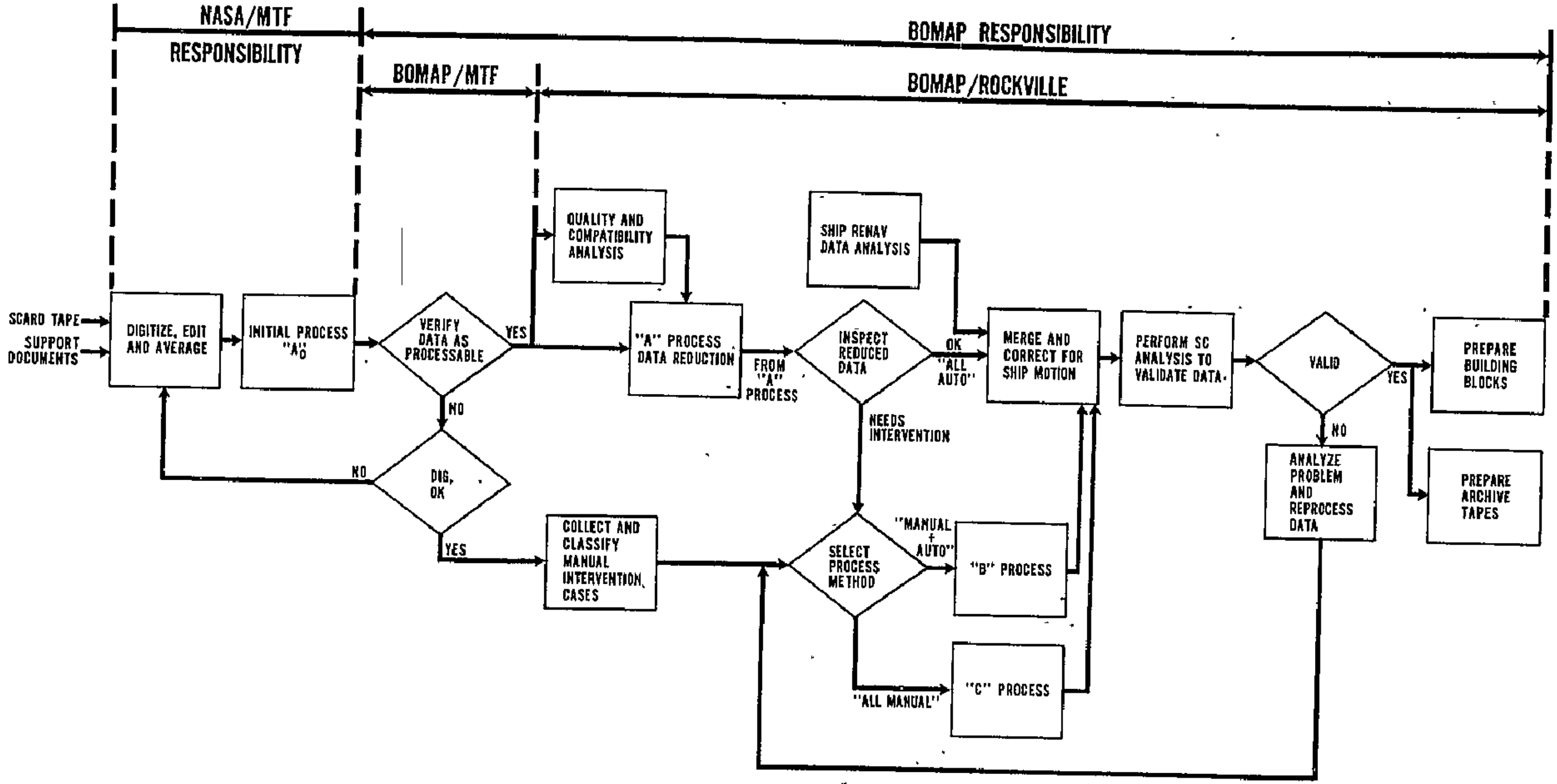

Figure 30.--Fixed-ship data reduction.

Aircraft Data Reduction

A general outline of aircraft data reduction is shown in figure 31; reduction of Research Flight Facility (RFF) data in figure 32; and reductio of Navy and Air Force data in figure 33. BOMEX Bulletin No. 5, section 3 part F, contains additional information on aircraft data reduction.

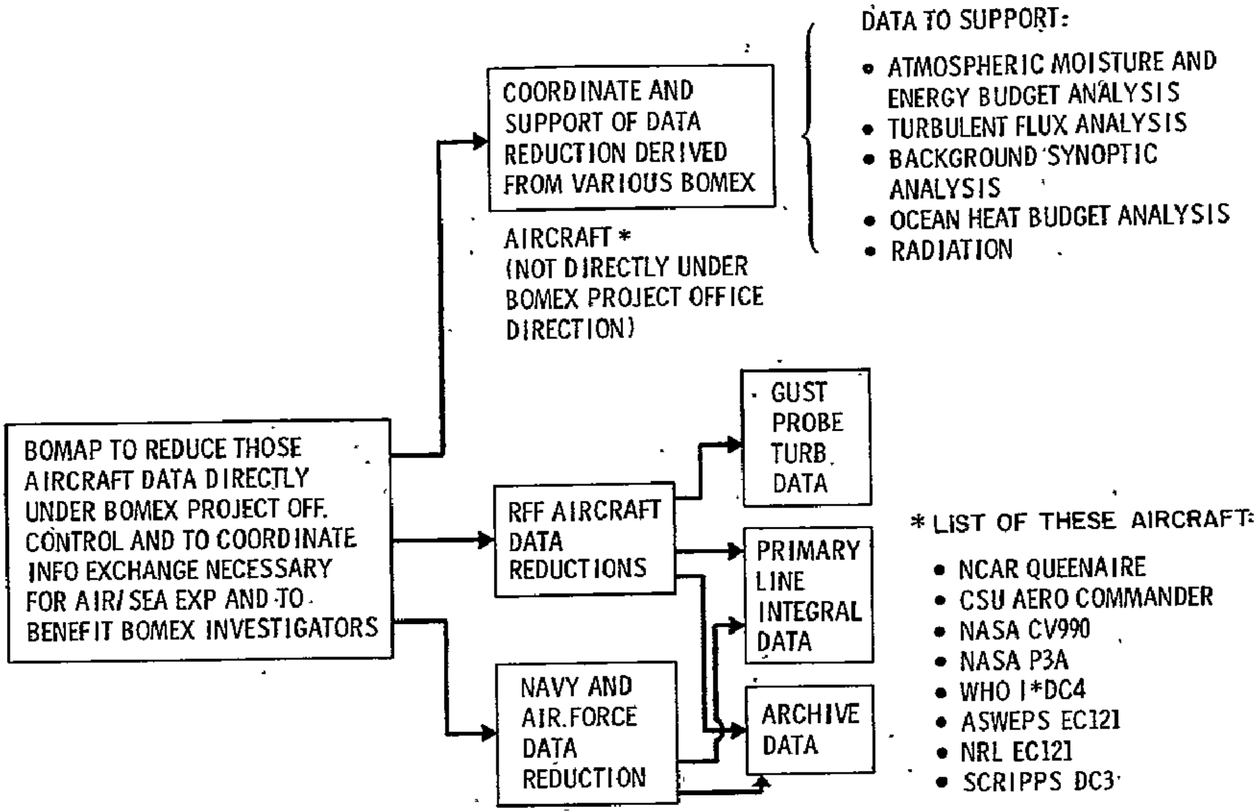

Figure 31.--Aircraft data reduction.

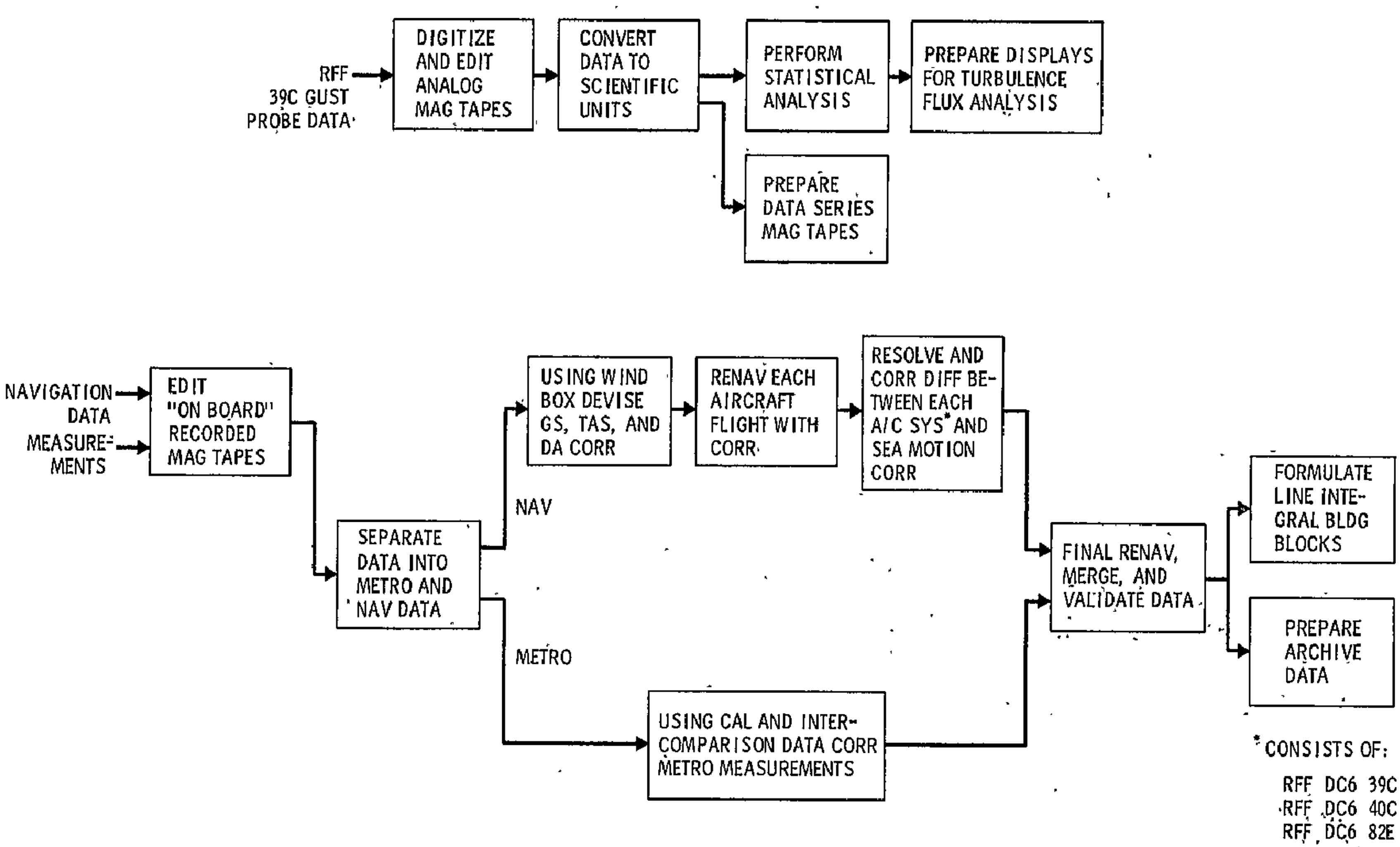

Figure 32.--RFF aircraft data reduction.

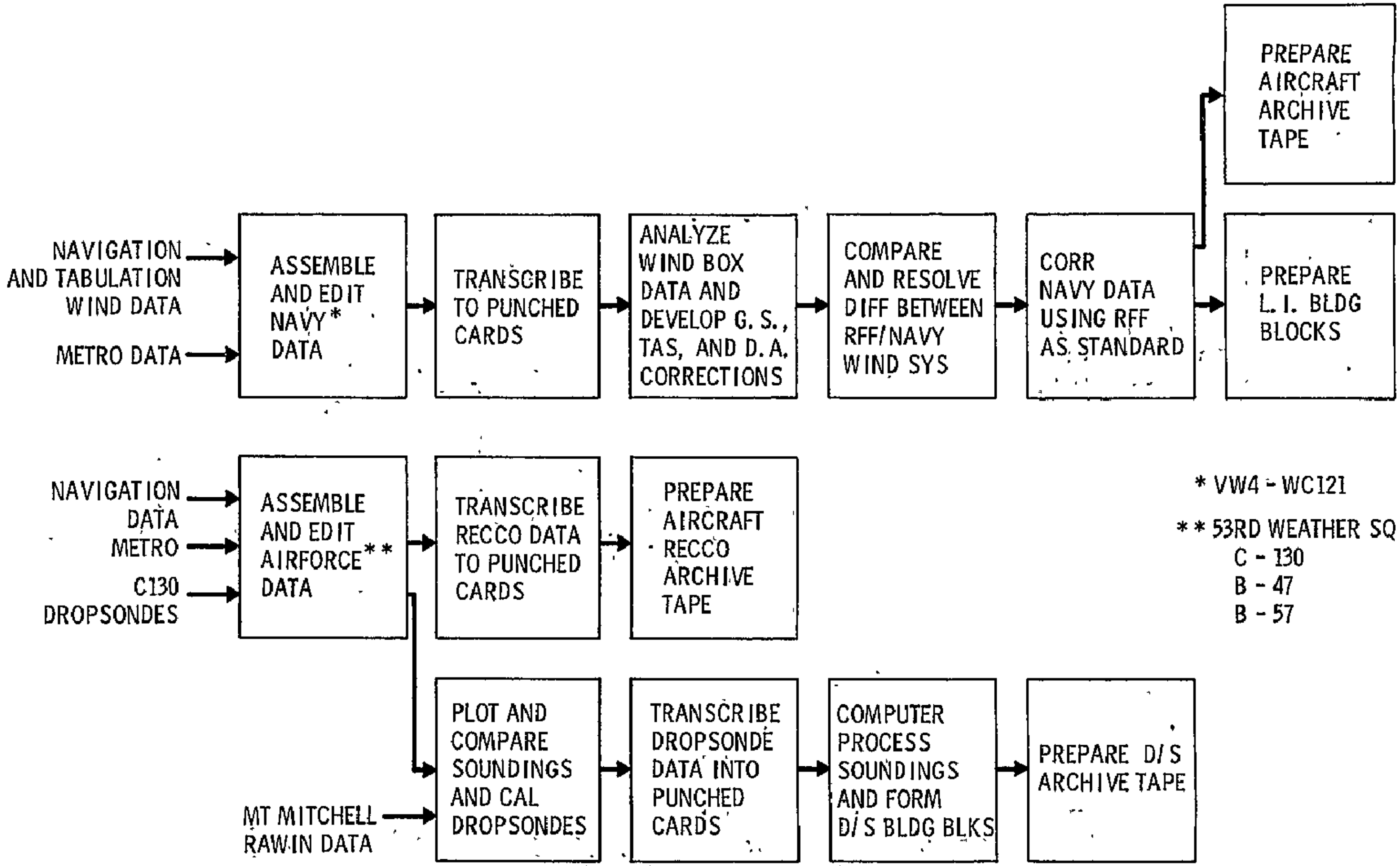

Figure 33.--Navy and Air Force aircraft data reduction.

Radar Data Reduction

A large quantity of radar data was obtained during BOMEX. The type of radar used and the quantity of photographs taken during the first three periods of field observations in support of the BOMEX core experiment are:

			Number of photos
I.	Surface based radar -- equipped for gain-stepping		
	A.	AN/MPS - 34, X-band (island based)	35,000
	B.	METEOR - 200, X-band (DISCOVERER)	15,000
		Subtotal	50,000
II.	Airborne radar -- no gain-stepping		
	A.	A.F. B-47, X-band	15,000
	B.	NAVY WC-121, S-band	3,500
	C.	RFF DC-6 & DC-4, S- and X-band	75,000
		RFF DC-6, K-band (RHI)	60,000
		Subtotal	150,000
		TOTAL	200,500

The surface based radar was equipped with gain-stepping, which made it possible to produce photographs showing only the stronger echoes. The principal objectives in the radar data reduction are shown in figure 34.

After completing the inventory and editing of radar photographs, the analysis of radar data will follow the five major flow patterns depicted in figure 35.

Numerical values must be assigned to extract quantative information from the radar photographs. Because of the large quantity of radar data in photographic form, this process will require certain streamlining, automation, and digitization. Examples of types of output from the radar data reduction follow.

- Spatial and temporal distribution of clouds summits.
- Echo size and coverage, temporal variations, interspacings, life-times, etc.
- Measured and estimated rainfall intensities.
- Time integrated, spatially averaged rain amounts.
- Rainfall intensity distribution $\longrightarrow$ comparison with rain gage and echo statistics.
- Echo size vs volume of precipitation measured $\longrightarrow$ latent heat distribution.

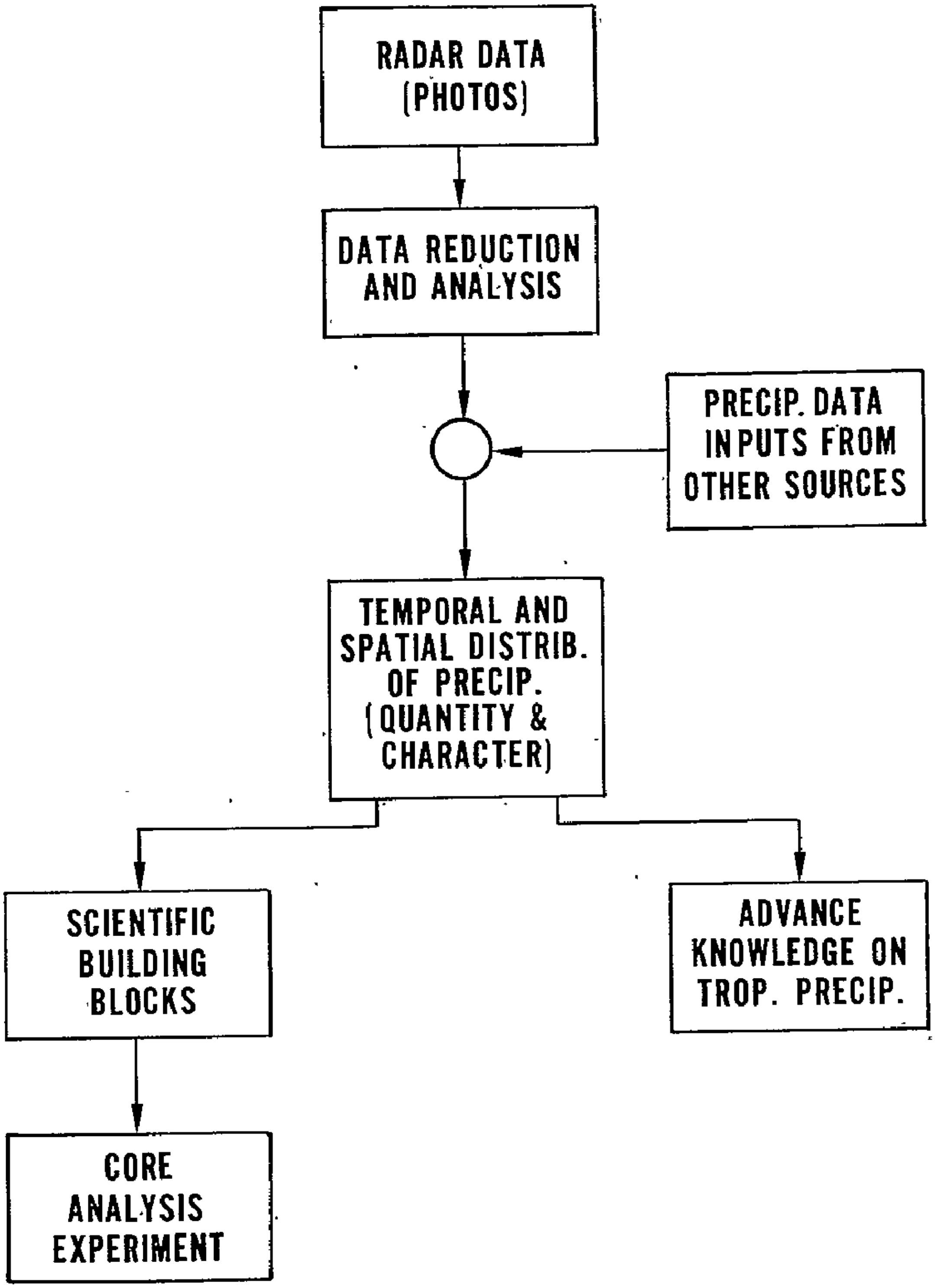

Figure 34.--Objectives in the radar data reduction.

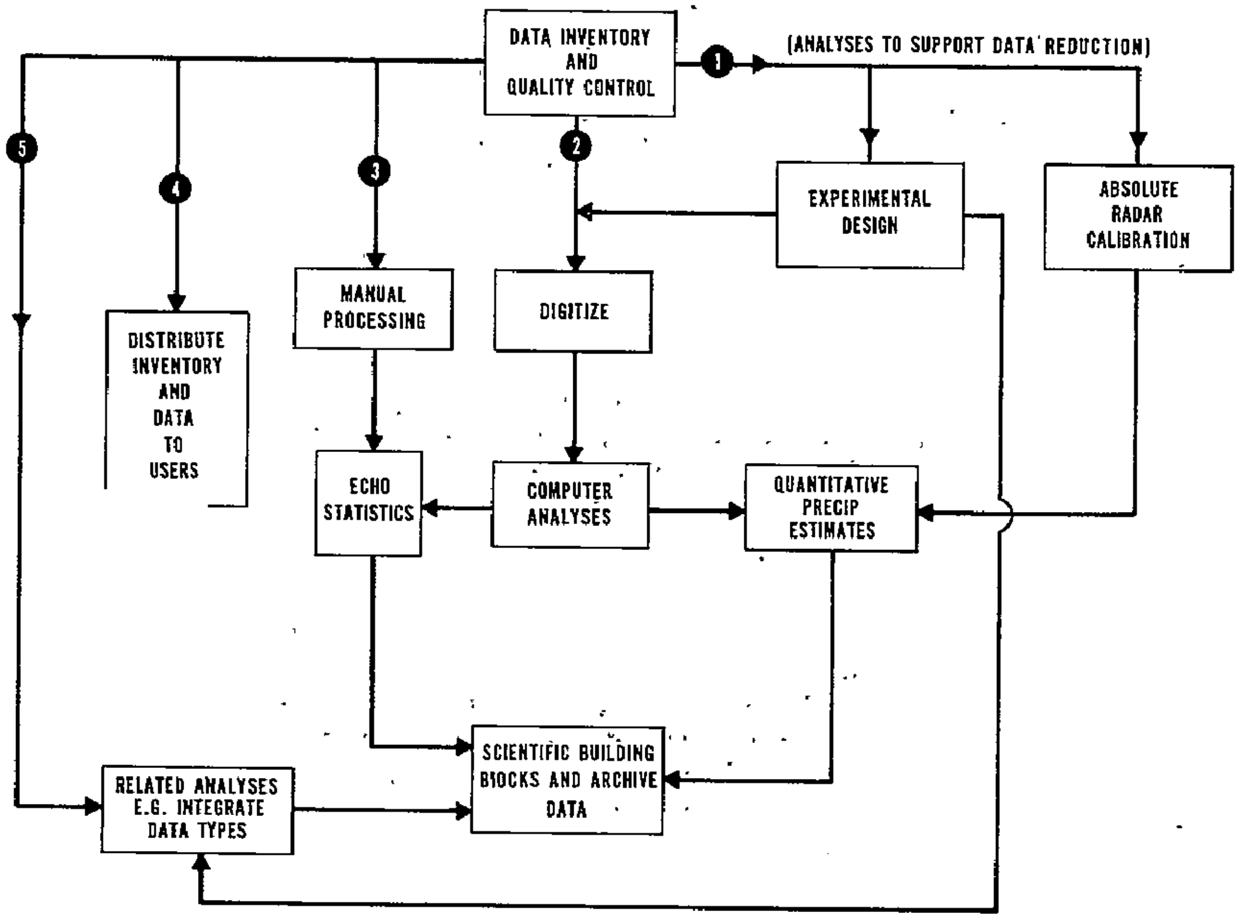

Figure 35.--Flow patterns in analysis of radar data.

Radiation, Precipitation, and
Cloud Data Reduction

The reduction of the radiation data is being performed by Dr. Kuhn, ESSA, and Dr. Cox, Colorado State University. The general outline of radiation data reduction is given in figure 36. The cloud, precipitation and radiation analysis is outlined in figure 37.

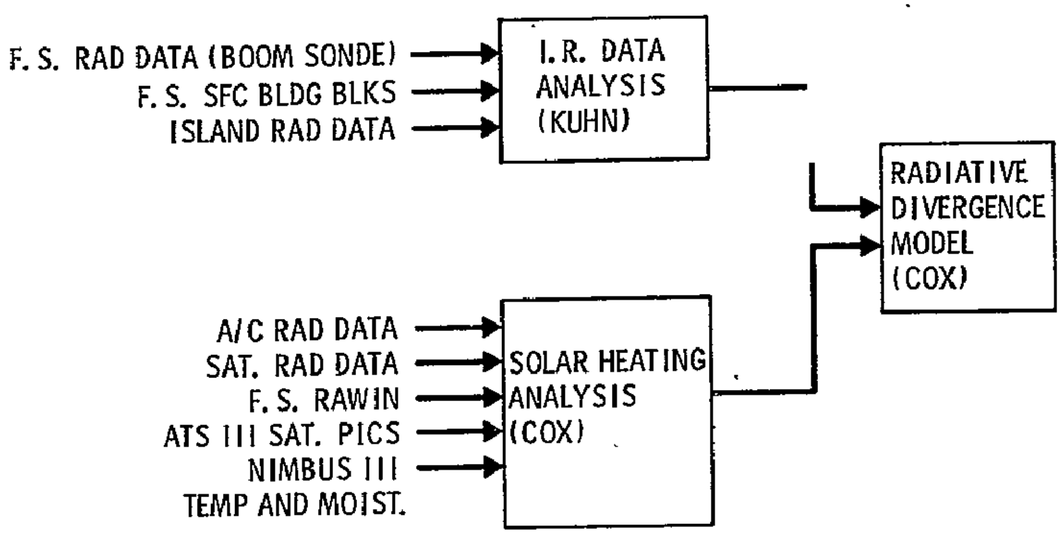

Figure 36.--Radiation data reduction.

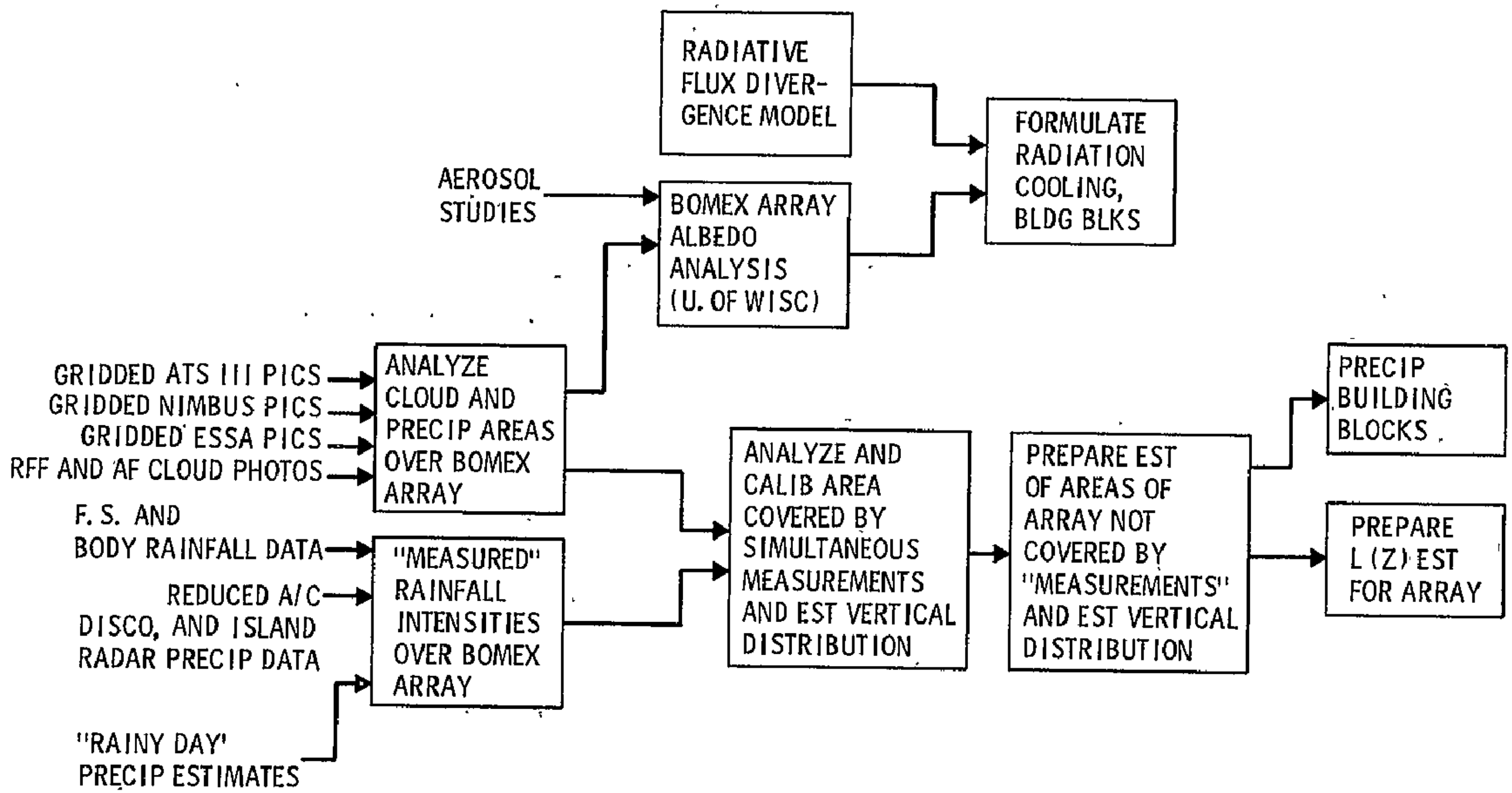

Figure 37.--Cloud, precipitation, and radiation analysis.

General Weather Data Reduction

The large amount of meteorological data that was acquired during BOMEX will be used to better understand and interpret the weather patterns during the field observations and as direct data input to the core experiment and other research programs. The overall plan for the reduction, display, interpretation, and analysis of the general weather data is shown in figure 38.

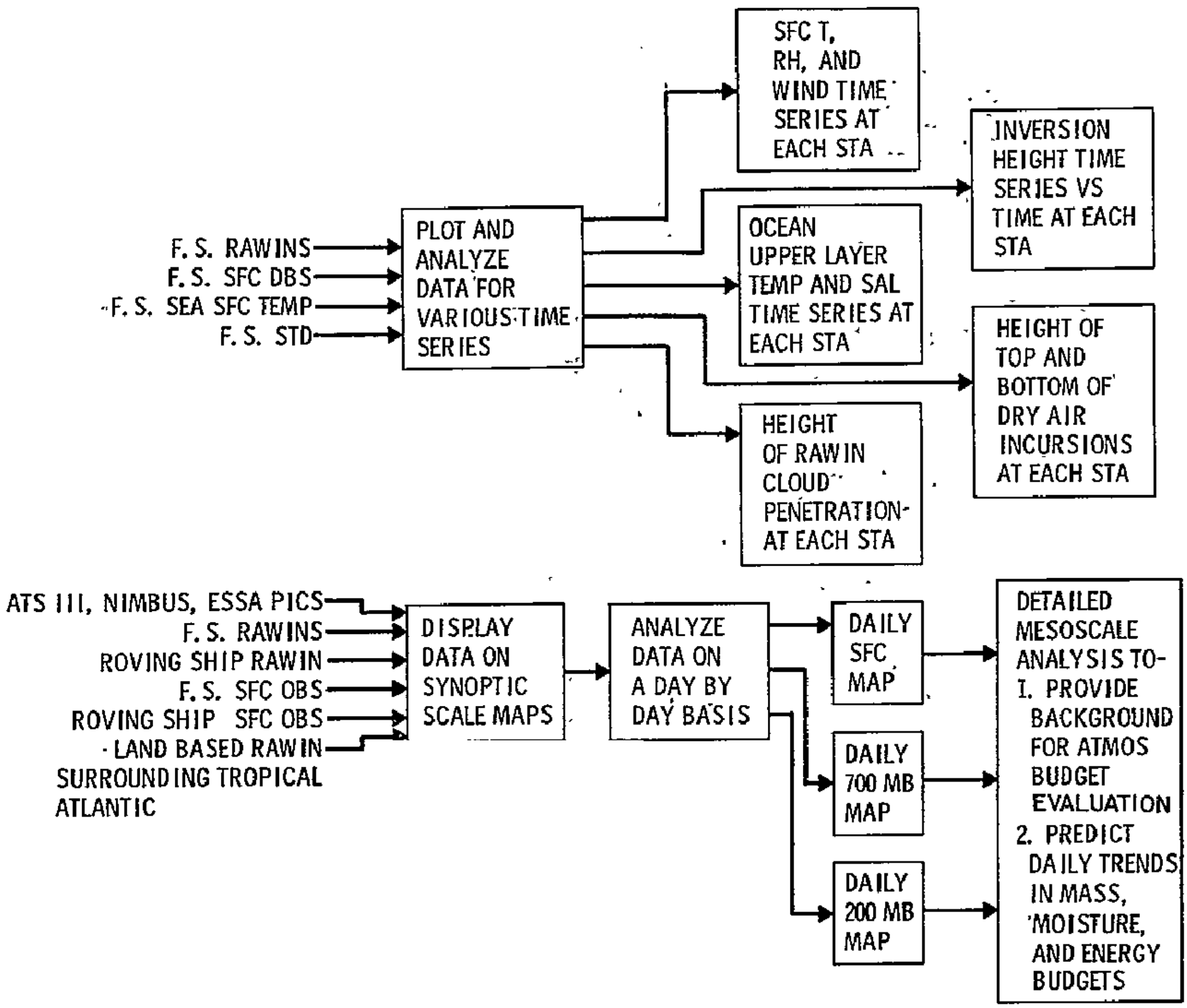

Figure 38.--General weather data reduction and analysis.

D. Statistical Analysis Plan

A fundamental objective of the BOMEX data collection was to estimate certain volume meteorological quantities, such as the average temperature of the BOMEX atmospheric box, at a given time. For the purpose of estimation, and the construction of confidence limits, the BOMEX box (which was roughly 500 kilometers square and 500 millibars of pressure differential high) was divided into a set of smaller working boxes stacked on top of each other -- each 500 km square and 25 mb of pressure differential high. The volume of any working box is referred to as a working volume. Volume meteorological quantities must be distinguished from point quantities. A point quantity is any observed quantity at a particular point in the BOMEX box. A volume quantity is defined as a function of the integral of the observed point quantity for all points of the volume that is under consideration. This discussion relates to estimation of quantities for a working volume. Estimation of volume quantities for the BOMEX box can be accomplished by summation over the working volumes.

Point meteorological quantities are classified as directly observable, such as temperature and relative humidity, and as derived quantities such as divergence. The point quantity may be a function of another point quantity such as the square of a point quantity or the product of one or more other point quantities.

In the definition of a volume quantity, every point of the volume enters into the definition. However, procedures for the estimation of a volume quantity must take into account the fact that observations are only available at selected points of the working volume.

The overall analysis problem can be divided into two parts, the definition task and the estimation task. The definition task consists of a listing or cataloging of the volume quantities that are to be estimated and appropriately defining them. Each definition is in three parts:

1. Definition of a point quantity,

2. Definition of the integration of the point quantity over the working volume, and

3. Definition of the required function of the result of the integration.

Formulation of definitions is complicated by the fact that the volume property usually varies with time. The average of the property over some stated time interval is the quantity to be estimated. The definition task is based entirely on meteorological theory and, in completing this task, it is important to be almost entirely divorced from considerations as to available data.

The estimation task begins with the definition of the volume quantities to be estimated. The data available for such estimation are of three types: Rawinsonde, dropsonde, and aircraft observations. The quality of the data varies for each of these sources; each source samples different points in the working volume; and each source has its own advantages and disadvantages. In general, observations are distributed through a time frame, which may be more or less correlated with the space frame.

The rawinsonde observations sampled vertical columns of air above the ships at the four corners of the BOMEX box. On some days there were four rawinsonde observations at each corner, each covering a time span of about 90 minutes. On days selected for intensive measurements, there were 15 rawinsonde observations at each corner, each covering a time span of about 45 minutes. Dropsonde observations sampled vertical columns of air at points spaced along the two diagonals of the BOMEX box and covered a time span of about 3 hours. Aircraft observations were made along an ascending path around the perimeter of the box and covered 8 to 12 hours.

The volume quantities to be estimated can be further classified into divergence quantities and nondivergence quantities.

A nondivergence quantity, such as the average temperature of a working box, requires either that one make an assumption as to nature of temperature variation within the box or make use of information as to the kind of variation. Only the dropsonde data contain information as to the nature of variation within the box.

One assumption that can be made in order to estimate average temperature is to assume that the temperature variation within the box is linear with respect to a rectangular coordinate system in the horizontal plane. If this assumption is made, an averaging of the rawinsonde temperatures at the four corners of the working box provides an unbiased estimate of the average temperature of the box.

Another approach is to assume that the variation of temperature within the box can be effectively described by a statistical model that has both linear and quadratic terms in a rectangular coordinate system. Such a model is

$$T = B_o + B_1x_1 + B_2x_2 + B_{11}x_1^2 + B_{12}x_1x_2 + B_{22}x_2^2,$$

where T is the temperature at point x_1, x_2 in the working box. In this coordinate system, the origin is located at the center of the box and the x's take the values of plus and minus one at the corners of the box.

Using the above statistical model, the average temperature over the box is

$$\bar{T} = B_o + (1/3)\ (B_{11} + B_{22}).$$

The parameter B_o is estimated as the mean of the four rawinsonde observations at the four corners. The quadratic parameters are estimated using least squares procedures from the dropsonde data. The dropsonde data do not contain information as to the value B_o because of a systematic bias in the dropsonde observations.

The estimation of divergence quantities such as water vapor divergence is facilitated by the divergence theorem, which makes it unnecessary to have information as to variation within the box. Estimation can be accomplished using information around the perimeter of the box. The rawinsonde data, primarily, and the aircraft data, secondarily, can be used to estimate the necessary perimeter quantities.

III. BOMEX PARTICIPANTS INFORMATION EXCHANGE

N71-32753

The status and progress of research projects, as reported by BOMEX participating experimenters through February 1970, follow. Experiment numbers refer to the listings in BOMEX Bulletins No. 4 and 5. Of special interest are the reports and papers already published and presented and the many reports and papers already scheduled for 1970.

EXPERIMENT 2: Spectra of Vertical Motions as a Function of Space and Time.

PRINCIPAL INVESTIGATOR: Louis A. Banchero

AFFILIATION: U.S. Naval Oceanographic Office

PROGRESS AND CURRENT STATUS: Data was not recovered for this experiment.

DATA AVAILABILITY: None

REPORTS OR PAPERS: None

EXPERIMENT 3: Spectra of Horizontal Motions as a Function of Space and Time to Determine Horizontal Current Scales.

PRINCIPAL INVESTIGATOR: Louis A. Banchero

AFFILIATION: U.S. Naval Oceanographic Office

PROGRESS AND CURRENT STATUS: All data recovered has been processed onto magnetic tapes. Data presently being reduced and analysis by computer programs.

DATA AVAILABILITY: After 1 July 1970.

REPORTS OR PAPERS: "Long-Term, Deep-Ocean Moorings of Current Measuring Arrays," Second Offshore Technology Conference, April 1970.

EXPERIMENT 6: IR Mapping of Sea Surface Temperature.

PRINCIPAL INVESTIGATOR: Miss Barbara Brennan

AFFILIATION: NASA/GSFC

PROGRESS AND CURRENT STATUS: Data reduction and analysis in progress.

DATA AVAILABILITY: March 1970 -- Some data is available now.

REPORTS OR PAPERS: Paper at AGU/AMS meeting April 1970: "Observations of Tropospheric Water Vapor Contrasts Near the ITC from Aircraft and Nimbus III During BOMEX," by Jack Conaway, B. Conrath, B. Brennan, and William Nordberg.

EXPERIMENT 8: Field Testing of a Balloon-Borne Optical Dew Point Hygrometer.

PRINCIPAL INVESTIGATORS: Frederick J. Brousaides and James Morrissey

AFFILIATION: AFCRL

PROGRESS AND CURRENT STATUS: Flight test evaluation has been completed.

DATA AVAILABILITY: February 28, 1970.

REPORTS OR PAPERS: "Differing Moisture Profiles in Radiosondings at Barbados," by Patrick J. Harney, to be presented at the AGU/AMS meeting in Washington, D.C. in April 1970.

"Interpretation of Dew-point Data from a Balloon-Borne Optical Hygrometer to the Range Refractive Index Measuring Problem," by Frederick J. Brousaides to be presented at the Fourth National Conference on Aerospace Meteorology at Las Vegas, Nev., in May 1970.

EXPERIMENT 9: Trade Wind Structure and Mixing Processes During BOMEX.

PRINCIPAL INVESTIGATOR: Dr. Andrew F. Bunker

AFFILIATION: Woods Hole Oceanographic Institution

PROGRESS AND CURRENT STATUS: The records containing the psychrograph, dew point, wind, pressure height, and solar radiation data have been read at one-minute intervals. Meteorological quantities have been computed, edited, checked and are now ready to be entered into the BOMAP data system. Reading of the turbulence and cloud records is now underway.

DATA AVAILABILITY: The psychrograph, wind, and solar radiation data will be immediately available from the BOMAP center. Turbulence and and turbulent fluxes should be ready by May 1970. Cloud cross-sections should be distributed by May or June 1970.

REPORTS OR PAPERS: None to date.

EXPERIMENT 10: Radon-222 and African Dust in the North Atlantic Trade Winds.

PRINCIPAL INVESTIGATORS: Dr. Joseph M. Prospero[1]; Dr. Toby N. Carlson[2]

AFFILIATION:
1. Rosenstiel School of Marine & Atmos. Sci., U. Miami
2. National Hurricane Research Lab., ESSA, Miami, Fla.

PROGRESS AND CURRENT STATUS: Average daily atmospheric dust load data for the entire summer has been worked up; several of the large dust events are being studied in detail. Much of the radon data has been processed.

DATA AVAILABILITY: Data should be available by late summer in the form of a technical report.

REPORTS OR PAPERS: "African Dust in the Trade Winds of the Northern Equatorial Atlantic Ocean," Joseph M. Prospero and Toby N. Carlson, AGU/AMS meeting in Washington, D.C. in April 1970.

"Radon-222 in the North Atlantic Trade Winds: A Tracer for African Air Parcels," Joseph M. Prospero and Toby N. Carlson, Ibid.

EXPERIMENT 11: Theory of Large Scale Atmospheric and Oceanic Processes

PRINCIPAL INVESTIGATOR: Dr. Jule Charney

AFFILIATION: Massachusetts Institute of Technology

PROGRESS AND CURRENT STATUS: Data not yet available for analysis.

DATA AVAILABILITY: Expect to have paper incorporating some of BOMEX data by July 1970.

REPORTS OR PAPERS: None

EXPERIMENT 12: Microwave Radiometer Measurement of Rain Cells

PRINCIPAL INVESTIGATOR: Dr. Jack Conaway

AFFILIATION: NASA/GSFC

PROGRESS AND CURRENT STATUS: Good

DATA AVAILABILITY: January 1970

REPORTS OR PAPERS: Expect to have a paper at AGU/AMS meeting in Washington, D.C. in April 1970.

EXPERIMENT 15: Directional Spectra of Surface Waves

PRINCIPAL INVESTIGATOR: Dr. Russ E. Davis

AFFILIATION: Scripps Institution of Oceanography

PROGRESS AND CURRENT STATUS: Data under analysis.

DATA AVAILABILITY: Preliminary results expected March 1970.

REPORTS OR PAPERS: None

EXPERIMENT 18: Spectral Albedo Measurement Program.

PRINCIPAL INVESTIGATORS: A.J. Drummond and J.R. Hickey

AFFILIATION: Eppley Laboratory

PROGRESS AND CURRENT STATUS: Analog tape date completely reduced and being distributed to interested experimenters -- NASA Goddard (Bandeen), BOMAP, ESSA (Kuhn), CSU (Marlatt), and U. of Wisconsin (Vonder Haar). More accurate digital data partially reduced and undergoing selection.

DATA AVAILABILITY: Analog data: immediate; Digital data: soon.

REPORTS OR PAPERS: "The BOMEX Solar Radiation Experiment: Some preliminary results," A.J. Drummond and J.R. Hickey, presented at Seattle, Wash., Symposium November 21, 1969.

EXPERIMENT 19: Tropical Weather Systems During BOMEX.

PRINCIPAL INVESTIGATOR: Dr. M. A. Estoque

AFFILIATION: University of Miami

PROGRESS AND CURRENT STATUS: Preliminary analysis of all data available from the original teletype transmissions has been completed.

DATA AVAILABILITY: Not applicable

REPORTS OR PAPERS: A report describing the results of the analysis described above will be available March 1970.

EXPERIMENT 23: Determination of the Turbulent Fluxes Near the Ocean.

PRINCIPAL INVESTIGATORS: Dr. R.G. Fleagle and Dr. Clayton A. Paulson

AFFILIATION: University of Washington

PROGRESS AND CURRENT STATUS: 1) Profile data analysis complete. 2) Some anemometer spectra and co-spectra in process of analysis. Coordination of analysis with the UBC aircraft data program and the OSU-UBC flux measurement (sonic anemometer and Lyman-α -humidiometer) data is underway.

DATA AVAILABILITY:
1) Profile data -- February 1970.
2) Samples of spectra & co-spectra June 1970.
3) Bulk of spectra & co-spectra December 1970.

REPORTS OR PAPERS: Presentation at AMS/U. of Washington Symposium on Early Results from BOMEX at Seattle, Wash., November 1969.

EXPERIMENT 27: Energy Dissipation in the Surface Boundary Layer; the Buoy Experiment.

PRINCIPAL INVESTIGATOR: Dr. Paul Frenzen

AFFILIATION: Argonne National Laboratory, USAEC, Argonne, Illinois

PROGRESS AND CURRENT STATUS: All data reduced (analog, pulsed records converted to 0.2 sec. winds); high-frequency spectra computed from all runs; preliminary momentum flux estimates computed from all runs; presently rechecking flux estimates and energy budgets.

DATA AVAILABILITY: In present format (0.2 sec. wind speeds, 3 levels, listings), now. High-frequency spectra following present recehck, about 1 March 1970.

REPORTS OR PAPERS: a) Paper (oral presentation): "Energy Dissipation in the Undisturbed Boundary Layer Over the Sea," given at Symposium on Early Results from BOMEX, Seattle, Wash., November 20-21, 1969. b) Paper (oral presentation); "A Comparison of Turbulent Energy Budgets in the Surface Boundary Layer Over Smooth Land and Open Sea," IUGG-IAMAP-AMS Symposium on Planetary Boundary Layers, Boulder, Colo., March 18-21, 1970.

Abstract: Results of a unique pair of experiments using virtually identical apparatus in very similar conditions of steady wind and near-neutral stratification are shown to indicate a marked difference between turbulent energy budgets near the surface over land and sea. Measurements of dissipation rates were obtained at three levels between 3 and 8 m above are extensive, uniformly smooth land surface in Australia and over the open sea during BOMEX. Exceptional care was taken to minimize distortion of the natural wind flow in each case: low-inertia cup anemometers were mounted on minimal structures; upwind fetches remained unobstructed and all support equipment was located more than 150 m downwind. Results indicate:

a) the value 0.49 for the Kolmogorov constant for the inertial subrange of the "downstream" spectrum (given by Pond et al.,'66) is closely confirmed;
b) the local dissipation assumption appears to be valid below 10 m in neutral conditions over smooth land surfaces;
c) in similar conditions over a sea surface with 1 m waves the same assumption fails; energy production by shear stresses is found to exceed the dissipatio- rate at each level by a quantity which can be estimated as u_*^3/z to a good approximation.

Possible causes of the observed difference in energy budgets are discussed and methods of correcting for the implied errors in wind stress estimates inferred from dissipation measurements are presented.

EXPERIMENT 30: Energy Budget of Barbados

PRINCIPAL INVESTIGATOR: B. J. Garnier

AFFILIATION: McGill University

PROGRESS AND CURRENT STATUS: All data from airborne observations with PRT-5 conducted June 25-28 and December 3-7, 1969, have been printed out by computer prior to developing appropriate analytical procedures. All instrument calibrations checked and completed.

DATA AVAILABILITY: Printout data now available. Adress inquiries to B. J. Garnier.

A Technical Report on methods of survey and instrument performance expected to be available June or July 1970.

REPORTS OR PAPERS: "A Report on Airborne Measurements of Earth Surface Temperature (Ocean and Land) in the 10-12u and 8-14u Regions," by M. Weiss, Chief Engineer, Barnes Engineering Company, Stamford, Conn.

EXPERIMENT 31: Synoptic Scale Energy Fluxes Between Tropical Oceans and Atmosphere.

PRINCIPAL INVESTIGATOR: M. Garstang

AFFILIATION: Florida State University

PROGRESS AND CURRENT STATUS: (a) Current meter data: 60 days at location 13 mi. east of East Point, Barbados, at 30 m (bottom of TRITON hull), 45 days processed, 15 days in process. Preliminary results available.

(b) Wave data (TRITON) in process, limited preliminary results showing one-dimensional wave spectra.

(c) Meteorological data (TRITON) 1968 data processed, initial results in press, 1969 data being processed, no results.

(d) Sub-cloud Instrument and Telemetry System (SITS) selected days processed, initial results published.

REPORTS OR PAPERS: (a) "A Sea-Air Interaction Deep-Ocean Buoy," M. Garstang, K. L. Warsh and P. Grose, Journal of Marine Research, January 1970.

(b) "An Observation of an Inertial Flow at Low Latitude," K. L. Warsh, K. L. Echternacht and M. Garstang, submitted to Journal of Geophysical Research.

(c) "Synoptic Scale Energy Fluxes Between Tropical Oceans and Atmosphere," M. Garstang -- Final Report to ESSA/BOMEX. Florida State University, December 1969.

(d) "Turbulent Structure of the Sub-Cloud Layer," Mr. Garstang, M. Murday and W. Sequin. Final Report to ESSA/BOMEX. Florida State University, December 1969.

EXPERIMENT 32: Radiative Balances and Fluxes in the Tropics.

PRINCIPAL INVESTIGATORS: Dr. John C. Gille and Dr. Michael Garstang

AFFILIATION: Florida State University

PROGRESS AND CURRENT STATUS: Portions on magnetic data tape are being edited.

Boundary Layer Radiative Flux Divergence is reduced in preliminary form.

Radiometersonde data is being reduced by ESSA (P. M. Kuhn).

Theoretical model programmed, now being made operational.

DATA AVAILABILITY: September 1970 (some may be earlier)

REPORTS OR PAPERS: Talk will be given at AGU/AMS meeting in Washington, D.C., in April 1970.

EXPERIMENT 33: Direct Dissipation Measurement

PRINCIPAL INVESTIGATORS: Dr. Carl H. Gibson, Dr. Gilbert R. Stegen, Mr. Carl Friehe

AFFILIATION: University of California at San Diego (Gibson, Friehe), Colorado State University (Stegen)

PROGRESS AND CURRENT STATUS: Hot wire and cold wire velocity and temperature signals have been analyzed for statistical parameters such as spectra, distribution functions, etc.. Values for Kolmogoroff's constant for the velocity inertial subrange are about 0.7, 40% larger than usually reported. Values for the temperature constant were found to be about 1.2, 300% larger than previously reported. The universal constant in Kolmogoroff's third hypothesis was found to be precisely ½ ± 5%. Drag coefficients inferred from the dissipation rate are $1.4 \pm 0.2 \times 10^{-3}$ referred to 10 meters at 5 meters per second.

DATA AVAILABILITY: Some now; much more analysis remains.

REPORTS OR PAPERS: "Statistics of the Fine Structure of Turbulent Velocity and Temperature Fields Measured at High Reynolds Number," Carl H. Gibson, Gilbert R. Stegen, Robert Bruce Williams -- to appear in Journal of Fluid Mechanics, 1970, Vol. 40, Part 2, pp. 888-999.

"Measurements of the Universal Constant in Kolmogoroff's Third Hypothesis for High Reynolds Number Turbulence," Carl H. Gibson, Gilbert R. Stegen and Steve McConnell, (submitted to Physics of Fluids).

EXPERIMENT 34: BOMEX STD Program.

PRINCIPAL INVESTIGATOR: D. V. Hansen

AFFILIATION: ESSA/AO&ML

PROGRESS AND CURRENT STATUS: Awaiting availability of verified core data.

DATA AVAILABILITY: ?

REPORTS OR PAPERS: None

EXPERIMENT 35: Wisconsin Atmospheric Radiation Divergence Study.

PRINCIPAL INVESTIGATORS: Dr. Kirby Hanson, U. of Wisconsin
Dr. Stephen Cox, Colorado State U.
Dr. Thomas Vonder Haar, U. of Wisconsin
Dr. Verner Suomi, U. of Wisconsin

PROGRESS AND CURRENT STATUS: Radiation data collected in the program on paper tape record has been placed on punch cards for subsequent processing. We are working directly with RFF to obtain listings of the RFF aircraft data for the flights on which we obtained radiation data. Computer software for the reduction of the radiation data is being written at present.

DATA AVAILABILITY: January 1971

REPORTS OR PAPERS: 1) "Radiation Experiment in the Vicinity of Barbados," Final Report on NSF Grant GA-12603, The Space Science & Engineering Center, U. of Wisconsin, April 1970 (at publishers at present time).

2) "Operational & Research Results of the Wisconsin Radiation Program in BOMEX," paper delivered at the AMS meeting on "Early Results of BOMEX" at Seattle, Wash., in November 1969.

EXPERIMENTS 37 & 38: Basic Synoptic Scale Water Vapor, Energy and Momentum Budgets.

PRINCIPAL INVESTIGATORS: Dr. J. Holland, Dr. A. Glaser

AFFILIATION: BOMAP Office

PROGRESS AND CURRENT STATUS: Data compatibility, error and calibration studies are underway with samples of fixed ship and line integral aircraft data.

SCARD data digitization has begun at MTF and Slidell.

Reduction of RFF data is now underway at NHRL. Methods are being developed for reduction and analysis of radar, cloud photo and satellite pictures. (See Part I "BOMAP Program" in this Bulletin.)

DATA AVAILABILITY: See BOMAP target dates, page 6, this Bulletin.

REPORTS & PAPERS: Oral presentations scheduled: IUGG-IAMAP-AMS Conference on Planetary Boundary Layer, Boulder, Colo., March 18-21, 1970; Annual Meeting of the National Academy of Sciences, Washington, D.C., April 27, 1970; AGU/AMS Meeting, Washington, D. C., April 1970; AMS/WMO international symposium on Tropical Meteorology, Honolulu, Hawaii, June 2-11, 1970; and WMO Commission on Atmospheric Sciences--V meeting, Washington, D. C., August 1970.

EXPERIMENT 41: Ocean Environmental Effects on Surface Schooling Tuna.

PRINCIPAL INVESTIGATOR: Dr. J.F. Hebard (Change of principal investigator)

AFFILIATION: BCF, TABL, Miami, Florida

PROGRESS AND CURRENT STATUS: (Not applicable)

DATA AVAILABILITY: July 1970

REPORTS OR PAPERS: None

EXPERIMENT 46: BOMEX Radiation Experiment.

PRINCIPAL INVESTIGATORS: P. M. Kuhn, L. P. Stearns

AFFILIATION: ESSA Research Laboratories, Atmospheric Physics and Chemistry Lab.

PROGRESS AND CURRENT STATUS: Twenty percent of the balloon radiation soundings have been analyzed from microfilms of the shipboard data. Third and fourth period data microfilms are being forwarded.

CV-990 radiometric observations simultaneous with lidar cloud geometric depth have been analyzed. Radiometersonde ascents indicate that high cirrus is the single most dominant factor in altering the radiative norm of the tropical Atlantic. This is not surprising since the magnitude of the reduction in available thermal power was up to a 40% decrease under cirrus, compared to cloudless conditions. This results in warmer trade cumulus cloud tops and somewhat higher tops. The contrast in cloud forms and atmospheric stability at the boundary between cloudless and cloudy tropical areas appears to be clearly evident.

DATA AVAILABILITY: Some at present; 75% by August 1970; 100% by October 1970.

REPORTS OR PAPERS: "Interaction of Radiation and Climate - BOMEX Experiment," manuscript submitted for publication in Journal of Geophysical Research.

"Altering the Tropical Radiation Norm," manuscript submitted for publication in Journal of Atmospheric Science.

EXPERIMENT 49: Graphic Results of Oceanographic Radio Message Data During BOMEX.

PRINCIPAL INVESTIGATOR: Robert C. Landis

AFFILIATION: The MITRE Corporation

PROGRESS AND CURRENT STATUS: Preliminary results completed.

DATA AVAILABILITY: Now

REPORTS OR PAPERS: "Preliminary Graphic Results of Oceanographic Radio Message Data During BOMEX," The MITRE Corporation M70-7, February 1970.

EXPERIMENT 51: Laser Radar Studies of the Marine Atmosphere

PRINCIPAL INVESTIGATORS: James D. Lawrence Jr., and Michael P. McCormick *

AFFILIATION: NASA/Langley Research Center
* Now with Fairchild-Hiller Corporation.

PROGRESS AND CURRENT STATUS: All laser radar data obtained have been digitalized and vertical profiles of the scattering function of the atmosphere are being prepared. In addition the calculations necessary to interpret the scattering profiles obtained with laser radar in terms of the vertical profile of aerosol particles are in progress. A number of direct sampling measurements of the surface aerosol size distribution were also obtained in the BOMEX area. These data have been processed and plots of the surface aerosol size distribution in the size range 0.5 to 5 microns have been prepared. The computer programs necessary to fit these measurements to aerosol models have been written.

DATA AVAILABILITY: It is estimated that the analyses of data obtained during BOMEX will be completed by May 15, 1970.

REPORTS OR PAPERS: None.

EXPERIMENT 56: NIMBUS III Study of Various Environmental Parameters.

PRINCIPAL INVESTIGATOR: William E. Marlatt

AFFILIATION: Colorado State University

PROGRESS AND CURRENT STATUS: Data has been summarized and published as Colorado State University Project Report.

DATA AVAILABILITY: Data report was disseminated to mailing list i early February 1970.

REPORTS OR PAPERS: Support Data for NASA CV-990 Meteorological Flight V, July 2 - July 29, 1969 -- L. Cole, L. Griffee, D. Hill, J. Ledgerwood, and W. Marlatt, CSU, Department of Atmospheric Sciences Report (Vol. 2)

EXPERIMENT 57: NIMBUS III Study of Aerosol Distribution.

PRINCIPAL INVESTIGATOR: W. E. Marlatt

AFFILIATION: Colorado State University

PROGRESS AND CURRENT STATUS: Data has been digitized and is presently being summarized and selected portions plotted.

Computer plotted data will be microfilmed by April 1970.

DATA AVAILABILITY: March 1970 (some sooner, depending upon format needed.)

REPORTS OR PAPERS: Manuscript on selected case study should be finished in a couple months.

EXPERIMENT 58: Measurement and Interpretation of the Sea-Surface and Air Temperature Gradients in the Sub-Cloud Layer During BOMEX.

PRINCIPAL INVESTIGATORS: W. E. Marlatt and W. Gray

AFFILIATION: Colorado State University

PROGRESS AND CURRENT STATUS: Most of data collected has been digitized and checked for calibration drift, missing values, etc. Summary tapes and printed output should be ready for analysis by mid-March.

DATA AVAILABILITY: Late March 1970

REPORTS OR PAPERS: None

EXPERIMENT 60: Navy Ocean Variability Studies East of Barbados.

PRINCIPAL INVESTIGATOR: Dr. P. A. Mazeika

AFFILIATION: NAVOCEANO

PROGRESS AND CURRENT STATUS: Data is being processed.

DATA AVAILABILITY: Approximately end of 1970.

REPORTS OR PAPERS: A study in preparation on the subsurface mixed layers.

EXPERIMENT 61: Sea Surface Temperature and Heat Flux.

PRINCIPAL INVESTIGATOR: Dr. E. D. McAlister

AFFILIATION: Scripps Institution of Oceanography

PROGRESS AND CURRENT STATUS: As indicated below.

DATE	TIME	WIND SPEED*	SEA SURF. TEMP.**	COMMENTS	HEAT FLOW RESULTS
24May	2227-2258Z	612	27.70	Intermittent rain squalls	0.05 cal cm^{-2} min^{-1}
26 "	2140-2238Z	890	28.05	Rain squalls nearby	0.24 cal cm^{-2} min^{-1}
27 "	0846-0952Z	830	27.70	Best weather	0.38 cal cm^{-2} min^{-1}
29 "	2124-2234Z	-	28.44	90% data lost: radar interference	0.4 cal cm^{-2} min^{-1}
25 "	2146-2238Z	650	27.60	External interference	Negative
19 "	2204-2255Z	795	27.95	Heavy weather; altitudes uncertain	Negative
24 "	1054-1124Z	770	28.10	Internal interference from power supply	Negative
28 "	0953-1023Z	830	-	High gusty winds; spray below 200' altitude	Negative

* From FLIP (cm/sec)
**°C - Average over one mile flight paths near FLIP

DATA AVAILABILITY: Complete results, which will include water surface temperature at 3-minute intervals during the times indicated on attached sheet, expected by early March 1970.

REPORTS OR PAPERS: 1) Sea Surface Temperature and Heat Flow - BOMEX. September 17, 1969, at Houston, Tex., NASA Hdqts., Earth Resources Program.

2) Preliminary Results on Heat Flow and Sea Surface Temperature - BOMEX. November 21, 1969, Seattle, Wash., Symposium on Early Results from BOMEX.

EXPERIMENT 64: Wind Tunnel Test of the Superstructure of the R/V FLIP.

PRINCIPAL INVESTIGATOR: Dr. Erik Mollo-Christensen

AFFILIATION: M.I.T.

PROGRESS AND CURRENT STATUS: Completed

DATA AVAILABILITY: Report circulated to ONR distribution list.

REPORTS OR PAPERS: Same as above.

EXPERIMENT 65: Photographic Study of the Generation and Concentration of Oceanic Whitecaps.

PRINCIPAL INVESTIGATOR: Dr. Edward C. Monahan

AFFILIATION: U. of Michigan

PROGRESS AND CURRENT STATUS: Photographs from 20 of our 64 field observation intervals have been analyzed to date. (All told during the 64 observation intervals some 4,500 whitecap photographs were taken.)

DATA AVAILABILITY: Our BOMEX results, combined with other oceanic whitecap data, will be ready for publication by the 1970 summer.

REPORTS OR PAPERS: None

EXPERIMENT 68: Numerical Simulations with BOMEX Data.

PRINCIPAL INVESTIGATOR: Dr. Joseph P. Pandolfo

AFFILIATION: Center for the Environment and Man, Inc.

PROGRESS AND CURRENT STATUS: Simulations have been run with space average initial vertical profiles and time average boundary data for June 21-25, 1966, from plotted raob data base.

DATA AVAILABILITY: All model-computed quantities are available on a continuing basis (see the following references for description of model outputs).

REPORTS OR PAPERS: 1) "A Numerical Model of the Atmosphere-Ocean Planetary Boundary Layer," (uses climatological data for BOMEX region). Proc. WMO/IUGG Symposium on Numerical Weather Prediction, Tokyo, November 26 - December 4, 1968 (March 1969).

2) "Preliminary Analysis of BOMEX Data Using a Numerical Boundary Layer Model," AMS/U. of Washington Symposium on Early Results from BOMEX, November 20-21, 1969, Seattle, Wash.

EXPERIMENT 69: Flux Computations by Aerodynamic Profile Methods.

PRINCIPAL INVESTIGATOR: Dr. Joseph P. Pandolfo

AFFILIATION: Center for the Environment and Man, Inc.

PROGRESS AND CURRENT STATUS: Awaiting reduction of BOOM and BLIP data at ship stations.

DATA AVAILABILITY: December 1970

REPORTS OR PAPERS: None

EXPERIMENT 72: The Three Dimensional Characteristics of the Tropical Subcloud Layer in the Mesoscale.

PRINCIPAL INVESTIGATOR: Dr. Herbert Riehl

AFFILIATION: Colorado State University

PROGRESS AND CURRENT STATUS: So far only the aircraft data from WHOI have been received by us for analysis. We are still waiting for RFF, NCAR, and U.S. Navy flight results and BOMEX land and ship soundings and surface data. Research can be complete within a month after these observations are received.

DATA AVAILABILITY: Unknown

REPORTS OR PAPERS: None

EXPERIMENT 73: Emergent Upwelling Irradiance

PRINCIPAL INVESTIGATOR: R. E. Payne

AFFILIATION: Woods Hole Oceanographic Institution

PROGRESS AND CURRENT STATUS: Analysis completed.

DATA AVAILABILITY: March 1970

REPORTS OR PAPERS: None

EXPERIMENT 74: Rn/Ra Measurements to Determine Vertical Mixing and Air-Sea Gas Exchange Rates.

PRINCIPAL INVESTIGATOR: Dr. David R. Schink

AFFILIATION: Teledyne Isotopes, Palo Alto Laboratories

PROGRESS AND CURRENT STATUS: The project is essentially complete. All field data have been reduced and the final technical report written.

DATA AVAILABILITY: All data are available to other scientists. A data summary has been submitted to NODC. The final technical report and data summary have also been sent to BOMAP.

REPORTS OR PAPERS: Final Technical Report: Schink, D. R., Sigalove, J. J., Charnell, R. L., and Guinasso, N. L., Jr. (1970) "Use of Ra/Rn Ratios to Determine Air/Sea Gas Exchange and Vertical Mixing in the Ocean, Final Technical Report," Teledyne Isotopes, Palo Alto Laboratories, PALTR-223.

Papers presented at meetings: Schink, D. R., Guinasso, N. L., Jr., Charnell, R. L., and Sigalove, J. J. "Radon Profiles in the Sea: A Measure of Air-Sea Exchange," presented at the Nuclear Science Symposium of the Institute of Electrical and Electronics Engineers, Inc., in San Francisco, October 29-31, 1969.

Schink, D. R., Charnell, R. L., Sigalove, J. J., and Guinasso, N. L., Jr., "Techniques for Studying the Dynamics of Dissolved Gas and Their Importance in Coastal Zone Planning," presented at the Symposium on Water Chemistry, American Chemical Society National Meeting in Houston, Tex., February 23-25, 1970.

EXPERIMENT 75: Shipboard - Buoy Rainfall Measurements.

PRINCIPAL INVESTIGATOR: Willard Shinners

AFFILIATION: ESSA - Sea-Air Interaction Lab.

PROGRESS AND CURRENT STATUS: Special shielded and non-shielded control rain gauges were provided Dr. M. Garstang for the TRITON buoy and Dr. Franceschini for the FLIP buoy to obtain quantitative rainfall data from these platforms; the 5 station ships were also provided rain gauges.

DATA AVAILABILITY: Precipitation and wind data are not yet available from the BOMEX data files.

REPORTS OR PAPERS: Paper: "Surface Meteorological Data Acquisition System -- BOMEX," presented at Seattle, Wash., meeting in November 1969.

EXPERIMENT 81: EDDY Flux and Profile Measurements from FLIP.

PRINCIPAL INVESTIGATOR: William J. Superior

AFFILIATION: C. W. Thornthwaite Associates

PROGRESS AND CURRENT STATUS: A final report "BOMEX Flux and Profile Measurements from FLIP" has been published and copies have been distributed to other interested scientists. This report includes data tabulations of wind profiles, air temperature profiles, wet bulb temperatures, wind direction, sky cover, air pressure, precipitation, and state of the sea for the period May 15 to May 28, 1969.

DATA AVAILABILITY: Data is presently available.

REPORTS OR PAPERS: Final Report, Contract N62306-C-9186, "Research BOMEX Flux and Profile Measurements from FLIP," March 19 to August 29, 1969, U. S. Naval Oceanographic Office.

EXPERIMENT 82: Physical Oceanography Feasibility Study Utilizing Satellite Data: BOMEX Sea-Surface Temperature Analysis.

PRINCIPAL INVESTIGATOR: Dr. Fred M. Vukovich

AFFILIATION: Research Triangle Institute

PROGRESS AND CURRENT STATUS: The analysis has been delayed by the unavailability of Nimbus III data. Results would be available in another 6 months.

DATA AVAILABILITY: June or July 1970 (possibly)

REPORTS OR PAPERS: None

EXPERIMENT 85: Classification of Environments About Tropical Cumuloform Clouds.

PRINCIPAL INVESTIGATORS: Victor S. Whitehead, Thomas L. Barnett, Ivan D. Browne

AFFILIATION: NASA/MSC

PROGRESS AND CURRENT STATUS: All data collected by the NASA NP3A has been formated and evaluated except those data from the filter wheel spectrometer.

A preliminary analysis of the data gathered during the first flight of the NASA NP3A has been performed. The analysis of the remainder of the data is in progress.

DATA AVAILABILITY: All data except that from the spectrometer is ready for transmittal to the BOMEX archives. A data users guide is in preparation. Samples of spectrometer data will be given in that guide; the remainder of the spectrometer data will be available after the most effective format is determined.

REPORTS OR PAPERS: "Data Collection by Use of the NASA NP3A Aircraft During BOMEX and Preliminary Results of Analysis," presented at the Symposium on the Early Results from BOMEX, Seattle, Wash. Copies are available and will be sent upon request.

EXPERIMENT 86: Basic Synoptic Scale Reynolds Stress Using the Geostrophic Departure Technique.

PRINCIPAL INVESTIGATOR: Scott L. Williams

AFFILIATION: BOMAP Office

PROGRESS AND CURRENT STATUS: Awaiting data reduction.

DATA AVAILABILITY: October 1970

REPORTS OR PAPERS: None

EXPERIMENT 93: Weather Radar Investigations on the BOMEX

PRINCIPAL INVESTIGATOR: Dr. Michael D. Hudlow

AFFILIATION: Formerly: Atmospheric Sciences Lab., U. S. Army
At present: BOMAP Office - ERL - ESSA

PROGRESS AND CURRENT STATUS: Experiment complete.

DATA AVAILABILITY: Presently available.

REPORTS OR PAPERS: Final technical report complete -- awaiting publication by ASL, ECOM, Ft. Monmouth, N. J. Should be available by April 1970.

EXPERIMENT 98: Sea Surface and Cloud Photography from CV-990.

PRINCIPAL INVESTIGATORS: Mr. John Semyan and Mr. William Vetter

AFFILIATION: NASA/GSFC

PROGRESS AND CURRENT STATUS: All pictures that were processed and considered satisfactory are available.

DATA AVAILABILITY: Now. There is a considerable expense incurred in duplicating data of this kind. Present budget will not permit general reproduction and distribution of these pictures. (As an example of the expense involved, the 70mm reprints alone would cost approximately $6,000.00). In the near future Colorado State University will issue a document listing support data for the NASA CV-990 meteorological flights (BOMEX) that will show essentially when cameras were in operation and any conditions that might be of interest to experimenters. If the experimenter can supply specific time code information to us, it may be possible to supply some specific photographs. We have also been informed that copies of entire flights may be acquired if the expense of reproduction is absorbed by the agency or experimenter requesting the service.

Colorado State University also has a complete set of video recordings that may prove valuable to some experimenters in the investigation of their data. Mr. Don Hill was in charge of recording on the plane. Availability of data unknown.

If any experimenter has a need to view the aforementioned photographs he may do so by coming to the Goddard Space Flight Center in Greenbelt, Md., Bldg. 21. Alternatives to this procedure will be considered if a request is made by letter to Dr. William Nordberg, NASA/GSFC.

REPORTS OR PAPERS: None

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IV. MISCELLANEOUS NOTES

a. The BOMAP Office has moved from Washington Science Center (WSC) Building 5 to North Bethesda Office Center (NBOC), 11420 Rockville Pike, Rockville, Md. 20852 -- telephone 301-496-8871. The mailing address is:

The BOMAP Office (Rx9)
Environmental Science Services Administration
Rockville, Maryland 20852

Visitors are welcome and desk space is available for those who wish to inspect data.

b. A BOMAP Advisory Panel has been established under the direction of the U.S. National Committee for GARP, NAS/NRC. The membership consists of:

Professor Alfred Blackadar, Pennsylvania State University
Professor Charles Cox, Massachusetts Institute of Technology
Professor Robert Fleagle, University of Washington, Chairman
Col. Thomas Haig, General Electric Corporation
Professor Noel LaSeur, Florida State University
Professor John M. Wallace, University of Washington
Dr. Edward Zipser, National Center for Atmospheric Research

A presentation was made by the BOMAP staff to the Advisory Panel, January 9, 1970, describing the history, goals, and plans for BOMAP. The BOMAP Advisory Panel, in a letter dated January 19, 1970, made the following suggestions:

"1. In addition to the responsibility for carrying out the "core" experiment of BOMEX and for facilitating exchange of data, the BOMAP Office should have certain specific but limited responsibilities in the areas of ocean analysis, analysis of mesoscale phenomena (including tropical convection), and satellite observations. For each of these areas a competent scientist should be appointed who would carry out research, provide liaison with external investigators, and contribute as appropriate to the fullest development of the core experiment. Examples of problems to be examined are:

Ocean data

Near surface heat budget and thermohaline mixing
Internal waves
Relation of evaporation and precipitation to
atmospheric parameters
Development of stratified layers

Scale interaction problems

Spectral analysis of time series data
Description of three-dimensional velocity, temperature,
and humidity in vicinity of convection cells and
cloud clusters and general mesoscale analysis
Diurnal phenomena

Satellite observations (ground truth studies)

IR temperature soundings
Velocities from cloud movements
Enhancement technique for identification of convective clouds

"2. An early look at limited samples of processed data would be extremely valuable. This would permit experimental calculations which would help to refine estimates of accuracy, would permit continual interaction between interpretation and data analysis, and would stimulate interest and imagination of the staff.

"3. The BLIP data provides unique information concerning low frequency boundary layer processes. The Panel recognizes the technical difficulties involved in processing the BLIP data, but urges that every possible effort be made to incorporate these data in the analysis routine at an early stage. The point made above regarding the importance of an early look is probably especially germane to the BLIP data."

c. The annual spring meeting of the American Geophysical Union and American Meteorological Society, to be held April 20-24, 1970, in Washington, D.C., will feature several symposia and discussion groups on the results of BOMEX.

d. An international Conference on Tropical Meteorology, cosponsored by the American Meteorological Society and the World Meteorological Organization, will be held at Honolulu, Hawaii, June 2-11, 1970. Topics include "Role of the tropics in the general circulation," and "Role of the tropics in the Global Atmospheric Research Program."

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